POWER PLANT ENGINEERING

Established Over 34 Years

VOL. XXXIV CHICAGO, JUNE 15, 1930 No. 12

EDITORIAL STAFF — ARTHUR L. RICE, Editor; R. E. TURNER, Managing Editor; A. W. KRAMER, Associate Editor; CHESTER R. EARLE, Associate Editor; RICHARD H. MORRIS, Associate Editor; EDWARD J. KUNZE, Associate Editor

Contents of this Issue

Page

Station A—San Francisco's New 1400-Lb. Steam Plant. By A. H. Markwart 664
W. S. E. Elects Officers 671
Comparison of Steam Station Performance. By A. G. Christie 672
The Air Map Versus the Missouri Mule. By A. W. Lee. 676
Putting the Power Company in the Front Yard. By John B. Reynolds 680
Frequency and Load Control on Electric Systems. By S. Logan Kerr 682
Unloading Frozen Coal Cars. By Edw. Luxemberg 685
Recent Developments in Embrittlement Research. By Frederick G. Straub 686
Planning Power Supply Systems for Large Cities. By A. H. Kehoe 688
New Plant Serves Oil Refinery 691
Power Supply System for Station Auxiliaries at the James H. Reed Station. By H. W. Eales 692
Diesel Engine Upkeep 699
Physical Factors in the Operation of Utilities. By Robert T. Livingston 702
Heating and Ventilating Delray No. 3. By Sabin Crocker 705
Women of Nebraska Power Co. Christen New Turbine ... 707
Powerton Makes Record for Economy 708
Power to Operate Conveyors. By Edward J. Tournier ... 710
Air Compressors and Receivers. By H. L. Kauffman 714
Water Supply Air Bound 716
Oxy-Acetylene Welded Piping Specifications 717
Double Belts from a Motor 717
Letters Direct from the Plant: Automatic Boiler Skimmer. Corliss Valve Setting Without Indicator. Limit Three-Phase Unbalanced Loads. Bracing Makes Cracked Cylinder Function. Fastening Angle Iron Endwise 718
Questions and Answers: No-Voltage Release Installation Eliminates Belt Slippage. Extraction Steam Quantity and Pressure 721
Editorial Comment: The Mechanized Coal Mine. Some Modern Works of Art 722
Off Duty 723
Bremo Bluff Plant to Have Interesting Features 724
Burner of New Design 725
New Conveyor Bearing 726
Master Switch for Magnetic Contactor Control 726
Weldomatic Arc Welding Head 727
New Crawler Loader 727
A. S. H. & V. E. at Minneapolis 728
One and a Half Million Horsepower 728
E. G. Bailey Receives Longstreth Medal 728
Death of P. A. Poppenhusen 728
News Notes 729
Catalog Notes 730
Power Plant Construction News 732

Published on the 1st and 15th of each Month by the
Technical Publishing Co., 53 West Jackson Blvd., Chicago
New York Office, 171 Madison Avenue

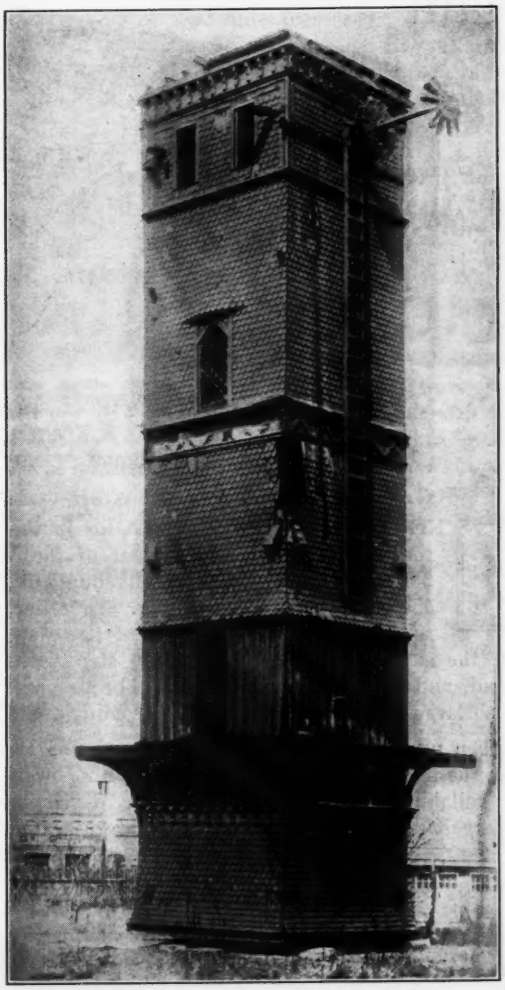
Subscription price $2.00 a year in the United States and possessions. Canada $2.75 a year. Other countries $3.50 a year. Single copies 15 cents.

Copyright 1930, by Technical Publishing Co.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Member, Associated Business Papers, Audit Bureau of Circulations.

Circulation of this issue 23,900



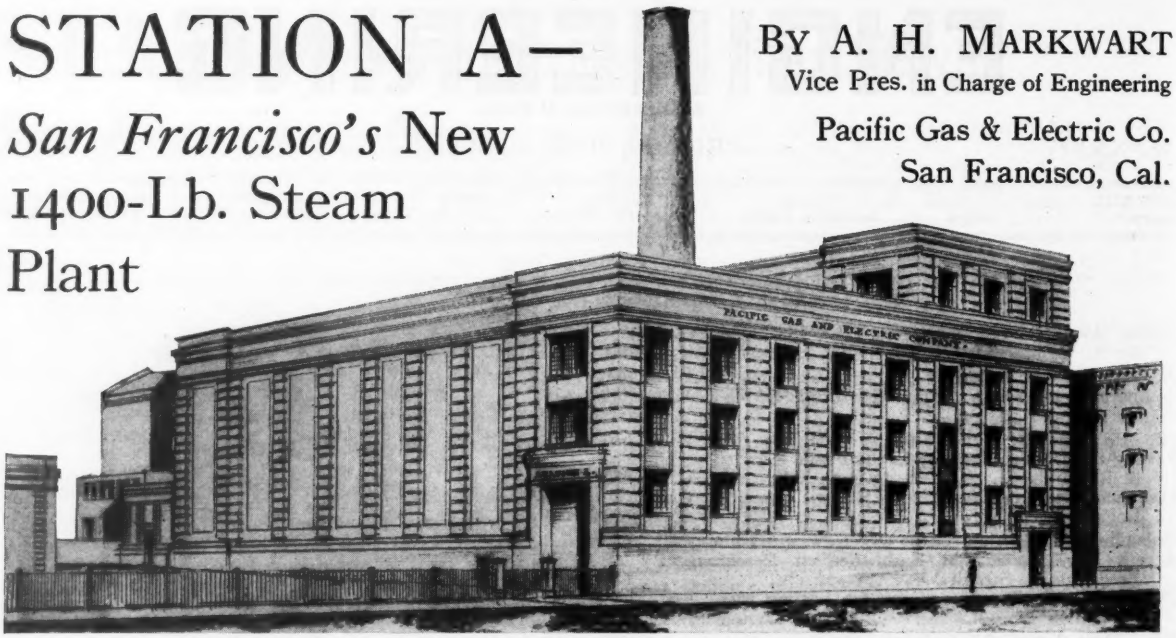
Ain't dat Sumpin'!

STEEPLE COMPOUNDING seems to be a characteristic of power plant designers. Of course no one would come right out and say that the new steeple compound turbo-generator announced a couple of years ago was not new—but here is the granddaddy of all electric power plants built by Chas. F. Brush in Cleveland many years ago and it's super-steeple compounded.

It is said to have been (the editor's rubber stamp "dictated but not signed" alibi) the first electric power plant in the world. Of course that's ancient history and, if you are interested in what a really modern steeple compound plant looks like, turn to the next page and see what San Francisco has to offer the engineer visitor this summer.

STATION A—
San Francisco's New 1400-Lb. Steam Plant

BY A. H. MARKWART
Vice Pres. in Charge of Engineering
Pacific Gas & Electric Co.
San Francisco, Cal.



CHANGING FUEL CONDITION INCREASES THE IMPORTANCE OF STEAM POWER TO WESTERN COMPANIES AND PACIFIC GAS & ELECTRIC CO. INCREASES CAPACITY OF STATION A BY THREE 10,699-SQ. FT., 1400-LB. BOILERS AND TWO 50,000-KW. VERTICAL COMPOUND TURBINES

ONE OF THE CHIEF FACTORS in the extensive industrial development of the West has been the presence of an abundant and cheap electric power supply. In order not to diminish the momentum of this development, the supply of power must keep step with the demand, and the electric utilities must be prepared to furnish large blocks of power over the coming years.

When used formerly in connection with the Pacific states, the term electrical power meant water power, for the availability of favorable hydraulic developments was largely responsible for the cheap power, steam electric energy being used only for carrying system peaks and for base loads in dry years to supplement deficient hydro supplies. It had been established fairly definitely over a period of years that on a typical large hydro system having a load factor of 65 per cent between 30 and 40 per cent of the total system capacity should be steam.

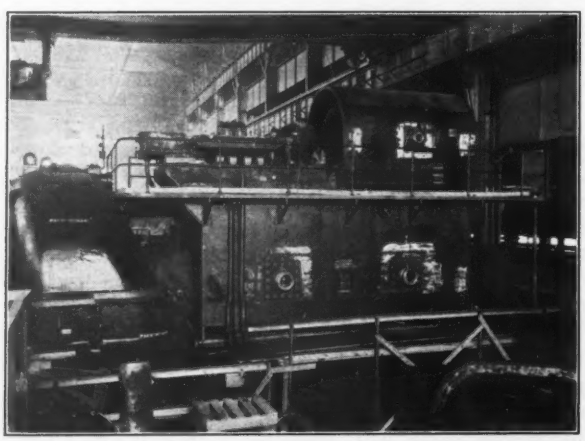


FIG. 1. SHOP VIEW OF THE FIRST STATION A 50,000-KW. VERTICAL COMPOUND TURBO-GENERATOR

Lowering of the cost of fuel, however, which has followed the spectacular growth of the oil industry in California and particularly the development of those fields, the utilization of whose oil depends upon the disposal of huge quantities of natural gas at even lower prices than obtained for oil, has quite reversed the situation. Steam power under certain circumstances can now be produced more economically than hydroelectric power and the larger western companies can now justify steam capacities of 80 per cent or more. With fuel prices promising to remain low for a time at least, the major portion of growth in the immediate future may be expected to be in steam development. In fact, hydroelectric development, when not in the nature of a particularly favorable economic situation, may now be looked upon mainly as a long pull investment, as a gamble upon an upward turn in the fuel market.

USE OF NATURAL GAS AS A FUEL CONSERVATION MEASURE

Development of hydroelectric projects has frequently been urged in the past as conservation measures for the fuel which otherwise would be wasted in needlessly generated energy. Now, in California the argument is equally significant in a reverse application to natural gas, the production of which, as a byproduct of oil, would be wasted were it not consumed for power generation. With such a sound basis in economics, the use

of steam in California for the production of electrical energy is thus growing more justifiable.

For Pacific Coast conditions and particularly for the system of the Pacific Gas and Electric Co., steam and water power sources are inherently interrelated in economic energy production. Steam is advantageously used to comb the peaks and thus give to the hydro plants the high load factor which is essential to their operating economy. Steam, to a rather large proportion of the total generating capacity of the system is necessary in supplying the hydro deficiencies of the annual low water seasons as well as periodic dry year conditions which must be met.

Steam is also made to "ride on the line," taking on the increments of load from day to day, while a hydro project is under development. By these means, only may the hydro plant be fully employed when it comes to completion. This is particularly to be desired in those comprehensive developments of streams with their larger blocks of power, which alone can make many hydro water power projects economically feasible.

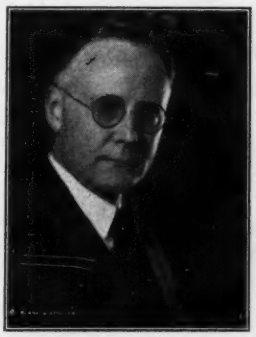
Thus the Pacific Gas and Electric Co. is continuing a program of 171,000 kva. in four plants on the Mokelumne River[1] begun some time ago and scheduled for completion sometime in 1935, while at the same time it has under construction a steam plant the first two units of which are to be completed early in 1931 and whose ultimate capacity is expected to exceed that of the entire Mokelumne River Development. The 81,000 kw. of increased steam capacity in the present program is, however, in the nature of steam supplement to the hydraulic plants on the Mokelumne River. The discussion to follow relates particularly to the features of the new steam development and the load conditions which brought it to pass. The population of northern California has increased 40 per cent during the past decade. In step with this growth, the Pacific Gas and Electric Co., which largely serves the area, has become one of the major electric and gas utilities of the United States. During the period 1919 to 1929, this company and its predecessors, including the Northern California Power Co., the Oro Electric Corp., the Sierra and San Francisco Power Co., the Western States Gas & Electric Co. and the Coast Valleys Gas & Electric Co., has increased from 1383.7 to 2787.0 million kw-hr., a growth of 101.4 per cent. In 1929 it generated 66 per cent of the 4240 million kw-hr produced in northern California.

In 1911 the installed capacity of the company comprised 60,000 kv-a. of steam and 145,000 kv-a. of water power, a total of 205,000 kv-a. At the close of last year, this installation had increased to 707,000 kv-a., of which 205,000 kv-a. was in steam and 502,000 kv-a. in water power.

Growth of load throughout this period has been remarkably uniform and close to the annual compounding increase. Thus as the total load has increased, the annual increments of load have increased. While at the present time 200 million kw-hr. per yr. are required, the average annual increase during the next 5 yr. will undoubtedly reach 250 million kw-hr. a year. Similarly the growth of peak for the next 5 yr. may be expected to average 45,000 to 50,000 kw. per year.

Results of load studies on the Pacific Gas and Electric system made 2 yr. ago, with the question of steam standby for San Francisco especially under consideration, indicated the advisability of increasing the capacity of Station A. The decision was reached that the maximum output possible should be provided at that point, as no other available location offered equal economic advantages.

Located upon the western shore of San Francisco Bay, in the Potrero district north of Hunter's Point the plant is where all the material aids to a successful steam plant are to be found. Excellent foundation strata, inexhaustible salt water cooling supply, proximity to the terminus of the company's natural gas transmission line or cheap delivery of fuel oil from tankers, and a location near the load center of San Francisco, all combine to make the location ideal. The plant is bounded on three sides by streets, and upon the fourth by the company's gas generating plant which circumscribes it and has given rise to many novel features in design.



A. H. Markwart, vice-president of the Pacific Gas & Electric Co., San Francisco, Cal., is a native of DuQuoin, Ill., but went to California at an early age. His preparatory education was completed in San Francisco at the Lick High School, after which he entered the University of California, graduating in December, 1903, as a Bachelor of Science in Civil Engineering.

His first important connection was with the old California Gas & Electric Corp., one of the predecessors of the Pacific Gas & Electric Co. In 1906 he became chief engineer and manager of the Syndicate Water Company of Oakland, Cal., and vice-president and manager of the Richmond (Cal.) Water Company.

Following the great San Francisco fire of April, 1906, Mr. Markwart became a junior member of the firm of Howard and Galloway, architects and engineers. The next year, he was in charge of the Seattle office of the same firm, engaged in the architectual and engineering design of the principal buildings of the Alaska—Yukon—Pacific Exposition. Following this, for four years he was back in general civil engineering practice in San Francisco as a member of the firm of Galloway and Markwart, consulting engineers, designing and constructing hydroelectric plants, irrigation systems, buildings and bridges.

With the launching of the plans for the Panama Pacific International Exposition in 1912, Mr. Markwart accepted the post of assistant director of works and chief of construction for that huge project. Upon the completion of this commission in 1915, he again returned to general civil engineering practice. At the outbreak of the World War, Mr. Markwart became affiliated with the shipbuilding industry on the Pacific Coast as a representative in shipbuilding loans and as general manager of one of the housing projects of the United States Emergency Fleet Corp.

In November, 1920, he was appointed director of engineering for the Pacific Gas & Electric Co., organizing a newly created engineering department and charged with the investigation and design of the elements of its rapidly growing system. Two years later, he was elected vice president in charge of engineering for the same company, the office which he now holds.

Station Will Use New Type Turbo-Generator

Station A has for many years been the main generating plant on the system. It was built originally in 1901 and at that time contained 5000 kw. in generating equipment, the form of reciprocating engines. Today, on the same location and in nearly the same building, a plant of 130,000 kw. capacity, of which 100,000 kw. is new, is being constructed, and an eventual capacity

[1] See page 575 of the May 15, 1930 issue for details of this development.

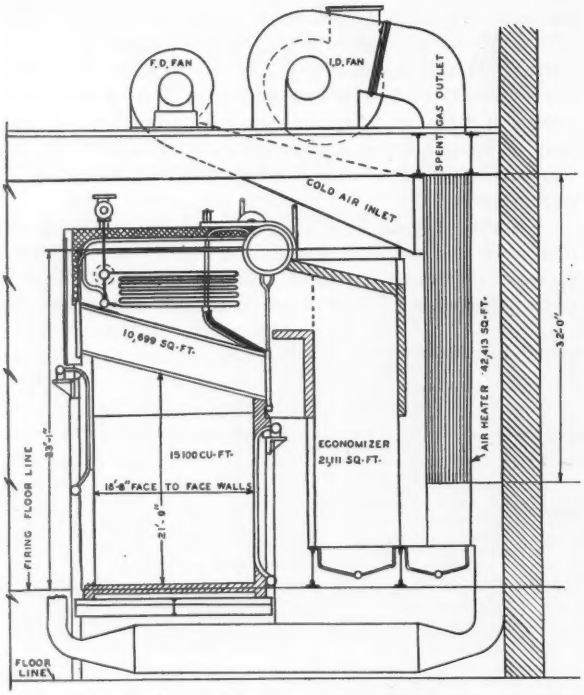


FIG. 2. ARRANGEMENT OF THE STANDARD BOILER ECONOMIZER AND AIR HEATER

of 200,000 kw. has been contemplated. References to capacity are in terms of name plate data. Throughout all the planning attendant to enlargement, the question of available space has been present and it has been a real problem to make this marked increase in capacity without any appreciable increase in space.

Plans, as finally prepared, contemplate the installation at present of two 50,000-kw. turbo-generators and three new boilers, and the removal of two 12,000-kw. turbo-generators and sixteen old boilers. The work outlined is being carried on as rapidly as possible. Most of the preliminary work has been completed. At the present time all of the 16 old boilers, the two vertical engines and the two vertical turbines have been removed. The foundation for one 50,000-kw. unit has been completed and the installation of the condensing equipment is now going on. Two of the three boilers are nearly complete and the third is well under way. No furnace construction has been done to date. The new switchhouse is completely framed, and the pouring of concrete is now going on. The building of the fifth story over the boiler room is nearly finished and will soon be ready to house the fans. The program contemplates having the first new unit ready in the fall of 1930, and the second new unit in service six months later. The final two 50,000-kw. units will be installed as soon thereafter as conditions require.

Design of the plant is being made by the Department of Engineering of the company. The steam-electric features are handled by the Division of Electric Distribution and Steam Engineering, of which S. J. Lisberger is in charge, with R. C. Powell in specific charge of the Station A work. The structural features are being designed by the Division of Civil Engineering, with I. C. Steele in charge.

Work at the site is being performed and supervised by the company's General Construction Department of which O. W. Peterson is engineer of general construction, with M. C. McKay, assistant engineer of general construction, in particular charge at the plant.

Descriptive data relating to the equipment and construction given below were prepared by E. A. Long, Assistant Engineer in the Department of Engineering.

Building

The station consists of a long narrow brick building divided by a heavy longitudinal wall with the major axis north and south. The boiler room is on the eastern side, and the turbine in the west. The boiler room has been partially rebuilt to accommodate the new boilers and fans. It was necessary to add one additional story to the structure, making this portion of the building five stories high. The lower four stories are occupied by the boilers and the fans will fill the fifth. Over the turbo-generators, the roof has been rebuilt to afford ample operating space above the new units. All roofing is of corrugated transite sheets. A 100-t. crane has replaced the former 50-t. equipment. The supporting rails were changed, but the masonry and steel supporting walls remain unaltered. A new switch house, four stories in height, on the western side of the generator room, is being constructed of steel and concrete. In this will be housed all the outgoing 11-kv. switching equipment.

Reconstruction has been carried on with as little interruption to the existing equipment as is physically possible. The most serious problems were encountered in the rerouting and temporary replacement of the existing steam lines. In the old station, the main steam

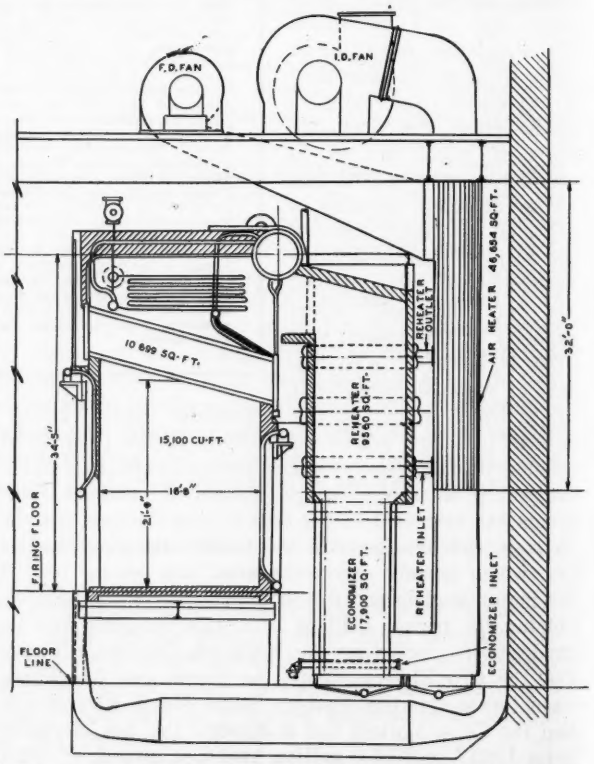


FIG. 3. THE REHEAT BOILER IS THE SAME AS THE STANDARD BOILER EXCEPT THAT A 9560-SQ. FT. REHEATER PRECEDES A SOMEWHAT SMALLER ECONOMIZER

header ran centrally through the boiler room, with branches to each unit upon the opposite side of the dividing wall. This 14-inch main was temporarily re-routed along the outside of the boiler room. Removal of old equipment was no small part of the work. The old turbines were sold for junk but the boilers were carefully dismantled and sold for re-use.

The discussion which follows covers chiefly the new equipment being installed in 1930, namely the two 50,000-kw. generators, the three 1400-lb. boilers and their auxiliaries.

Boilers for 1400-Lb.

Boilers are of Babcock and Wilcox make, of the cross drum type, consisting of three units, one standard boiler and two reheat. The water tubes and general arrangement of the standard and reheat boilers are the same. Each has 10,699 sq. ft. of heating surface and each is capable of evaporating 500,000 lb. of steam per hour at 1350-lb. gage and 750 deg. F. Each boiler is equipped with economizers and air preheaters. The difference between the two types lies in the arrangement of economizers and reheat elements.

In the standard boiler shown in Fig. 1, the economizers reach the entire length of the flue gas down-pass. In the reheat boilers shown in Fig. 2, the economizers occupy the lower portion of this space; and above, in the order named, are located the live steam reheaters and the flue gas reheaters. A steam and water drum, 60 in. in outside diameter and 51 ft. in length, extends across the rear of the boiler and is connected by circulating tubes to the 62 sections. Each section consists of 8 tubes, 3¼ in. in diameter, $\frac{11}{32}$ in. thick and 20 ft. long. The lower ends of the sections are connected to a forged steel mud drum 7¼ in. square. The connections throughout are made by expanding the tubes into bored tube sheets. The tubes, nipples and circulators are made of hot-finished, seamless, open-hearth steel.

Casing for the exterior of the boiler setting is of wrought steel. The boiler top and the upper part of the boiler front are constructed of removable insulated panels of No. 10 gage inner and outer plates. Similar panels 2 ft. wide, form the sides above the water walls. A single casing covers the cylindrical portions of the steam drum.

Insulating material for the side casing will consist of 4 inches of fire backing; for the boiler top, 6 in.; and around the drum shell, 3 in. Drum heads are covered with a 3-in. thickness of 85 per cent magnesia. All drums and tubes, except the water walls, superheater and reheater tubing, will be protected with two coats of Apexior.

Water-Cooled Walls

On each boiler the four furnace walls are furnished with Bailey water-cooled furnace wall equipment. With a furnace volume of 15,100 cu. ft., the wall surface of each reheat boiler will take care of an input of 675,000,000 B.t.u. per hr., while the standard boiler will handle 573,000,000 B.t.u. The furnace height from the firing floor to the under side of the boiler uptake header is 23 ft. 10 in. All boiler fittings and piping are equipped with Sarlun flanges and secured with alloy steel high strength studs. Before being placed in operation, all piping will be tested to 2500 lb. hydraulic pressure.

Burners employed are Peabody combination gas and oil type. There are 22 burners in the standard boiler, each designed to use 21,000 cu. ft. of gas per hour, or 1290 lb. of fuel oil. The total fuel consumption per hour will be 462,000 cu. ft. of gas, or 28,400 lb. of oil. In each of the reheat boilers, there are 26 burners. The consumption per burner per hour is estimated to be 21,600 cu. ft. for gas or 1346 lb. for oil, or a total per hour of 562,000 cu. ft. of gas, or 35,000 lb. of oil. The oil burners employ no steam for atomizing purposes. The heated oil is delivered to the burners at a pressure of 250 lb. per sq. in. and is atomized in passing through the burner-nozzle. Natural gas is delivered into the station through a pressure regulator, which maintains a pressure of 10 to 12 lb. in the line. From the regulator, the gas is conducted through a manifold to the various burners.

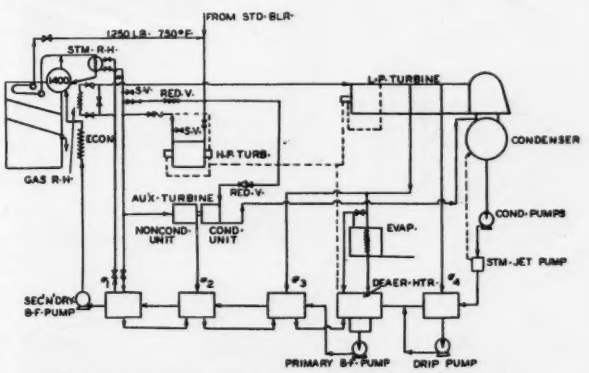


FIG. 4. HEAT BALANCE DIAGRAM OF STATION A
(Steam flows and temperatures at a maximum load of 63,000 Kw. are given in Fig. 3, page 1351 of the December 15, 1929 issue)

Burners in each furnace are to be controlled through master valves, one for gas and one for oil, and the change from one fuel to the other may be made quickly. It is possible also to change rapidly from stand-by operation to full-load firing with this arrangement.

For stand-by service, the gas fuel has proven more satisfactory than oil, because the burners may be operated with a mere candle flame without the flame going out, a condition which cannot be duplicated with oil fuel.

Forced and Induced Fans

All fans are electrically driven and are located above the boilers on a fan floor. They are Sturtevant movable-vane of the downward-discharge type and are each direct-connected to two constant-speed induction motors of different powers and speeds. This arrangement was decided upon to secure the most efficient stand-by equipment at times of light load.

At light load, the smaller, lower speed motors will drive the fans. When full load is added, the larger and faster motors will drive the equipment. The intermediate quantities of air are secured by changing the position of the movable vanes on the fans. Each boiler is provided with one induced and one forced draft fan. The sizes of the driving motors vary from 150 hp. to 1100 hp., tabulated in the accompanying equipment list.

Air preheaters are of the tubular type and of two

sizes. On the standard boiler, the heater has an area of 42,413 sq. ft.; in the reheat boilers, they have an area of 46,654 sq. ft. each. Both economizers and boilers are equipped with Diamond Automatic Valve soot blowing equipment. The standard boiler has 14 units installed; each economizer has 16; there are 14 in each reheat boiler and 24 in each reheat economizer and reheater.

Feedwater System

Boiler feedwater is handled in two stages. The three primary feed pumps, which are electrically driven by 600-hp., 2300-v. constant speed induction motors equipped for across-the-line starting, raise the pressure of the feed to 600 lb. per sq. in. The three secondary feed pumps are driven by steam turbines and raise the

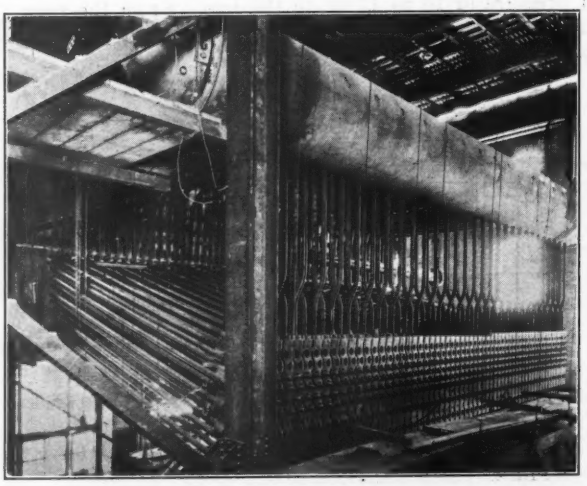


FIG. 5. ONE OF THE 1400-LB. BOILERS DURING ERECTION

water to the final pressure of 1625 lb. per sq. in. at 431 deg. F. All of these pumps are six-stage Camerons, each having a capacity of 600,000 lb. per hr. The heat balance of the station determined the choice of steam-driven rather than electrically-driven secondary pumps. Two of these secondary feed pumps are driven by two 1250-hp. turbines each.

Each of these 1250-hp. turbines is constructed for operation at 300 lb. gage and 600 deg. F.; one is condensing and the other is noncondensing. The noncondensing turbine takes steam from the cross-over between the high-pressure and the low-pressure main turbines and exhausts into the No. 2 feedwater heater. This turbine operates with throttle wide open at all times. The condensing turbine takes steam through a desuperheater from the 1350-lb. steam header and exhausts into the condenser of the main turbo-generator. The third secondary feed pump is driven by a single condensing 1250-hp. turbine. This unit is for stand-by and emergency use and supplements the two duplex units.

Arrangement of the main feedwater system is indicated in the flow diagram, Fig. 3.[2] Condensate is delivered to the jet pumps where it picks up 1,200,000 B.t.u. per hr. and then passes at a temperature of 86 deg. F. into the No. 4 heater where steam, fed from the 14th stage of the low-pressure turbines, raises the temperature to 90-171 deg. F., depending upon the load. From No. 4 heater the feed flows into the deaerating heater where air is removed. Both No. 4 and the deaerating heaters are open heaters. From this point, the flow enters into No. 3 heater where the temperature is brought to 199-269 deg. F. Heater No. 2, which has been previously mentioned, then raises the temperature of the water from 258 deg. to 348 deg. F. and when it leaves No. 1 heater it has attained the temperature of from 230-431 deg. F. Heaters Nos. 1, 2 and 3 are of the closed type.

All makeup water is evaporated from the public water supply, which is first treated in a hot lime and soda softener. The makeup is estimated at 1.7 per cent of the throttle flow. Three single effect evaporators of 260 sq. ft., each with a capacity of 10,000 lb. per hr. from 212 deg. F. feed furnish the makeup. The turbine is bled at the 10th and 14th stages for feedwater heating and evaporating duty and the final heating of the feed is secured from the cross-over header on the exhaust side of the high-pressure unit. These stage heaters are either vertical or horizontal, the selection of each type being made on the basis of space available. Feedwater regulation is cared for by a Bailey flow meter, an installation which automatically maintains constant water level height in the boilers through regulation of the speed of the boiler feed pumps.

Turbo-Generator

Two General Electric vertical, cross-compound type turbo-generators are being installed. In technical interest, these units share honors with the high-pressure boilers. The arrangement of these units is shown in Fig. 4 and is quite unusual. Each unit consists of two turbines and two generators, one a high-pressure unit and the other a low-pressure unit operating on reheated steam from the exhaust of the high-pressure unit. The rating of the high-pressure unit is 12,500 kw. This unit operates at 3600 r.p.m. on steam supplied at 1200-lb. gage and 750 deg. F. Steam is exhausted at a maximum pressure of 450 lb. The low-pressure unit is rated at 37,500-kw., and operates at 1800 r.p.m. Its exhaust pressure is 1¼ in. abs.

At the time the unit was planned, the rating was specified as 50,000 kw. Calculations now indicate that the unit will possess considerable overload capacity. This increased capacity is limited, not by the generator winding, but by the increased pressure within the turbine shell. The nameplate rating will remain at 50,000 kw., but the unit will be capable of generating 65,000 kw. when supplied with 1250 lb., 750 deg. F. steam with a back pressure of 1¼ in. abs. of mercury and with the top heater cut out.

The entire casing for the high-pressure element, as well as the high-pressure side of the low-pressure element, is of cast steel. The low-pressure casing and the exhaust hood of the low-pressure elements are of cast iron. Packing for both high-pressure and low-pressure elements are of the combined labyrinth and water seal type. Non-corrosive, stainless steel alloys are used extensively in water impellers, casings, rings, nozzle partitions and similar parts.

Bearings are of cast iron, babbit lined and self-alining. The thrust bearing is of the marine type. All

[2] A flow diagram with steam quantities and temperatures for the maximum load of 63,000 kw. is given on page 1351 of the December 15, 1930 issue.

Station A, Pacific Gas & Electric Co., San Francisco, Cal.

BOILERS AND ECONOMIZERS

BOILERS. Three Babcock & Wilcox Co. water tube, one standard, two reheat. Effective heating surface each 10,699 sq. ft., 60-in. cross drum 51 ft. long, 4-in. thick; 62 sections of eight 3¼-in. seamless steel tubes 20 ft. long. Maximum pressure 1400 lb. per sq. in. Capacity 500,000 lb. of steam per hour.

SUPERHEATER. (Standard boiler) Babcock & Wilcox Co., return bend, 5-loop wrought steel for 750 deg. F. steam.

SUPERHEATER. (Reheat boilers) Babcock & Wilcox Co., return bend, 4-loop, wrought steel for 750 deg. F. steam.

ECONOMIZERS. (Standard boiler) Babcock & Wilcox Co., counterflow, return bend, 28 tubes wide, 48 tubes high, 21,111 sq. ft. heating surface.

ECONOMIZERS. (Reheat boilers) Babcock & Wilcox Co., counterflow, return bend, 30 tubes wide, 38 tubes high, 17,900 sq. ft. heating surface.

FLUE GAS REHEATERS. (Reheat boilers) Babcock & Wilcox Co. for 1400 lb. steam, 9560 sq. ft. heating surface.

LIVE STEAM REHEATERS. (Reheat boilers) Babcock & Wilcox Co. for 1400 lb. steam, 2689 sq. ft. heating surface.

SAFETY AND RELIEF VALVES. Edward Valve & Mfg. Co.

BLOWOFF VALVES: Babcock & Wilcox Co. on boilers, two 2½-in. in tandem. On economizers, two 2½-in. in tandem.

WATER COLUMN. Babcock & Wilcox Co. flat glass.

BOILER VALVES. Edward Valve and Mfg. Co., 6-in. boiler stop and check valves, hand operated, for 1625-lb. pressure 450 deg. F. 12-in. boiler stop and check valves, with Sarlun flanges, hand operated, for 1350-lb. steam and 750 deg. F.

BOILER VALVES. Chapman Valve & Mfg. Co., 10-in. and 12-in. motor operated for 1350-lb. steam and 750 deg. F. 14-in. and 20-in. motor operated for 600-lb. steam.

BOILER VALVES. Crane Co., 6-in. and 8-in. motor-operated and hand-operated for 1350 lb. and 750 deg. F.

SOOT BLOWERS. Diamond Power Specialties Co. automatic valve. 14 units in each standard boiler, 16 units in each economizer, 14 units in each reheat boiler, 24 units in each economizer and reheater.

FEEDWATER REGULATOR. Bailey Meter Co. control.

FURNACES, with four Fuller Lehigh Co. Bailey Water Walls each. Furnace volume 15,100 cu. ft., B.t.u. input per hour standard boiler 573,000,000 and reheat boiler 675,000,000.

BURNERS. PEABODY ENG. CO. Combination Gas and Oil. 22 in. standard boilers, 26 in. reheat boilers.

FEEDWATER SYSTEM

14TH STAGE HEATER. (No. 4) Two Foster Wheeler Corp., open vertical type, 1950 sq. ft., 636 ¾-in. O. D. No. 18 B. W. G. Admiralty tubes. Capacity 425,000 lb. per hr., 125 lb. working pressure.

DEAERATING HEATER. Two Cochrane Corp. steel plate, open type, delivering 500,000 lb. per hr. at 30-lb. working pressure.

STORAGE TANKS. One 1500-gal. hotwell storage, one 7000-gal. overflow tank, one 20,000-gal. for emptying boilers, one 60,000-gal. on fan floor for general storage.

EVAPORATORS. Three Cochrane Corp. single effect evaporators, 260 sq. ft., 25-lb. working pressure, capacity 10,000 lb. per hr. from feed at 212 deg. F. and 23 lb.

10TH STAGE HEATER. (No. 3) Two Foster Wheeler Corp., closed horizontal, 1634 sq. ft., 486 ¾-in. O. D. No. 16 B. W. G. Admiralty tubes, capacity 575,000 lb. per hour, 700-lb. working pressure.

NO. 2 HEATER. Two Foster Wheeler Corp., closed horizontal, 1634 sq. ft., 486 ¾-in. O. D. No. 16 B. W. G. Admiralty tubes, capacity 575,000 lb. per hour, 200-lb. working pressure. Steam from exhaust of high-pressure auxiliary turbine.

CROSSOVER HEATER. (NO. 1) Two Foster Wheeler Corp., closed floating head, vertical, 1450 sq. ft., 412 ¾-in. O. D. No. 16 B. W. G. Admiralty tubes, capacity 575,000 lb. per hr., 500-lb. working pressure.

TANK PUMPS. Three Ingersoll-Rand Co., Cameron HMT., 6-stage primary pumps, capacity 600,000 lb. per hr. at 235 deg. F. driven by General Electric Co. 600-hp., 2300-v., 3-phase cross-the-line starting motors.

BOILER FEED PUMPS. Three Ingersoll-Rand Co., Cameron HT., 6-stage secondary pumps, capacity 600,000 lb. per hr. at 431 deg. F. driven by auxiliary turbines. (See Auxiliary Turbines.)

DRIP PUMPS. Two Foster Wheeler Corp. pumps handling 67,000 lb. per hour at 180 deg. F., driven by 7½-hp., 220-v., 3-phase, induction motors.

DRAFT SYSTEM

STACKS. One steel stack 200 ft. high above boiler floor, 24 ft. in diameter (no taper). Erector unknown at present date.

DUCT WORK AND FLUES. Steel sheets, expansion joints of asbestos composition, non-metallic. Breeching 14 ft. by 20 ft.

FORCED DRAFT FAN. (For standard boiler) one B. F. Sturtevant Co. without inlet boxes, Type ID, No. 1006, 135,000 c.f.m. at 80 deg. Driven by one 500-hp., 900-r.p.m. and one 150-hp., 600-r.p.m. General Electric Co., 2300-v., 3-phase, constant speed induction motor.

FORCED DRAFT FANS. (For reheat boilers) two B. F. Sturtevant Co. without inlet boxes, Type ID, No. 1009, 165,000 c.f.m. at 80 deg. F. Driven by one 600-hp., 720-r.p.m. and one 150-hp, 450-r.p.m. General Electric Co. 2300-v., 3-phase, constant speed induction motor.

INDUCED DRAFT FAN. (For standard boiler) one B. F. Sturtevant Co., Type ID, No. 1009, 240,000 c.f.m. at 385 deg. F. Driven by one 750-hp., 900-r.p.m., and one 200-hp., 600-r.p.m. General Electric Co. 2300-v., 3-phase, constant speed induction motor.

INDUCED DRAFT FANS. (For reheat boilers) two B. F. Sturtevant Co., Type ID., No. 101, 290,000 c.f.m. at 385 deg. F. Driven by one 1100-hp., 900-r.p.m. and one 350-hp., 600-r.p.m. General Electric Co. 2300-v., 3-phase, constant speed induction motor

AIR PREHEATER. (For standard boiler) Babcock & Wilcox Co., tubular, 32 rows of 70 2½-in., 11 B. W. G. vertical tubes, 42,413 sq. ft. heating surface.

AIR PREHEATER. (For reheat boilers) two Babcock & Wilcox Co. tubular, 32 rows of 77 2½-in., 11 B. W. G. vertical tubes, 46,654 sq. ft. heating surface.

SERVICE EQUIPMENT

COOLER PUMPS. Raw cooling water from main salt water system for air cooler.

GLAND SEAL PUMPS. General Electric Co. with automatic pressure relief valves.

WATER SUPPLY from city mains.

FIRE PROTECTION from city water mains.

AIR COMPRESSORS—none

TURBINE ROOM CRANE. Judson Pacific Co., 100-t.

TURBINE OIL SYSTEM. By General Electric Co. Geared pump on low pressure unit and auxiliary steam driven pump for emergency water-cooled oil cooler. Oil tank capacity 1425 gal.

INSTRUMENTS—not yet purchased.

BOILER ROOM CONTROL. Automatic control by Bailey Meter Co. Vane setting of induced and forced draft fans, speed of feedwater pumps, amount of fuel consumed and height of feedwater.

TURBO-GENERATORS

MAIN GENERATING UNITS. General Electric Co. Two cross compound bleeder type, condensing, each unit having a total rated capacity of 50,000 kw., consisting of one high-pressure and one low-pressure element. HIGH-PRESSURE ELEMENTS. Steam conditions 1200 lb. per sq. in., 750 deg. F. total temperature, exhaust pressure 350 lb. maximum. Generator rated at 12,500 kw., 3600 r.p.m., 12,000-v., star connected. LOW PRESSURE ELEMENTS. Steam conditions 350 lb. sq. in., 750 deg. F., exhaust pressure 1¼-in. mercury abs. Generator rated 37,500 kw., 1800 r.p.m., 12-000-v., star connected.

EXCITERS. General Electric Co., direct connected to low-pressure element. 250-kw., 250-v. Pilot exciters, 5-kw., 250-v., direct connected to main exciter.

AIR COOLERS. General Electric Co., surface type, four sections of 4190 sq. ft. each, raw cooling water.

OIL COOLERS. Raw, water-cooled.

OIL PUMPS. General Electric Co., driven by gearing from shaft of low-pressure element.

VENTILATING FANS. Integral with generator rotor.

AUXILIARY TURBINES. General Electric Co., 3600 r.p.m. Two sets of two turbines in tandem driving each boiler feed pump. Each set consists of one 1250-hp. condensing, steam taken from main steam header through reducing valves, and one 1250-hp. noncondensing, steam taken from crossover between high and low-pressure turbines of main units.

SPARE PUMP UNIT. One General Electric Co. 1250-hp., 3600-r.p.m., condensing turbine driving the spare boiler feed pump.

DUAL DRIVE EXCITER. Westinghouse Elec. & Mfg. Co., consisting of one 100-kw., 250-v. exciter driven by one 150-hp., 2300-v. cross-the-line-starting constant speed induction motor and one 230-hp., type 3 AMD., 400 lb. per sq. in., 750 deg. F. steam turbine.

SPARE EXCITERS. General Electric Co., two 250-kw., 250-v. units, driven by 375-hp., 2300-v. cross-the-line constant speed induction motors.

CONDENSING EQUIPMENT

CONDENSERS. Foster Wheeler Corp. Two cylindrical type, 2-pass surface condenser, 34,000 sq. ft. (33,500 sq. ft. in condenser, 500 sq. ft. in external air cooler) with tubes expanded into rigid tube sheets at both ends.

JET PUMPS. Foster Wheeler Corp. twin element, 2-stage.

HOTWELL PUMPS. Foster Wheeler Corp., two per condenser, 6-in., type NS, 3-stage, capacity 900 g.p.m., driven by 60-hp., 230-v., 3-phase wound rotor variable speed induction motors.

STEAM JET EXHAUSTER. One Foster Wheeler Corp. special on each condenser.

SALT WATER COOLING PUMPS. Two 1250-hp. and one 700-hp., 2300-v. General Electric Co. cross-the-line starting motors driving Union Iron Works salt water pumps, capacity 55,000, 55,000 and 40,000 g.p.m. respectively.

MISCELLANEOUS

TRAVELING SCREEN. Link-Belt Co., 10 ft. wide by 30 ft. high on two intake gates.

TURBINE LOAD INDICATING EQUIPMENT. General Electric Co. Selsyn.

MAIN TRANSFORMER BANKS. General Electric Co., 4 2500-kva. units 12,500/2,500-v. serving 3 1500-kva. 4,150-v. city feeders.

AUXILIARY TRANSFORMER BANKS. General Electric Co., 8334-kv-a., 12500/2500-v., 3-phase, with 250-v. tertiary winding.

CIRCUIT BREAKERS. General Electric Co., 15-kv. truck type.

MAIN SWITCHBOARD. General Electric Co.

AUXILIARY SWITCHBOARD. Westinghouse Elec. & Mfg. Co.

250-VOLT STATION PANELS. Diamond E Electric Co.

DISCONNECTING SWITCHES. General Electric Co. and Electric Power Equipment Co.

NEUTRAL REACTORS for main generators 8100 amp., 49,200-kv-a., by General Electric Co.

are arranged for forced lubrication and cooling by means of oil. In addition to the main oil pump, geared to the turbine, there is an auxiliary steam-driven oil pump automatically controlled. These are mounted on the low-pressure turbine and take care of the requirements for both elements.

Governor Control

When operating as a compound unit the governor of the high-pressure turbine controls the set. There are also two operating governors on the low-pressure unit, to provide for control when the low-pressure element is operating directly from the boilers, with the high-pressure element shut down. One of these will control the speed by means of a valve in the high-pressure steam line. The second functions as a pre-emergency control

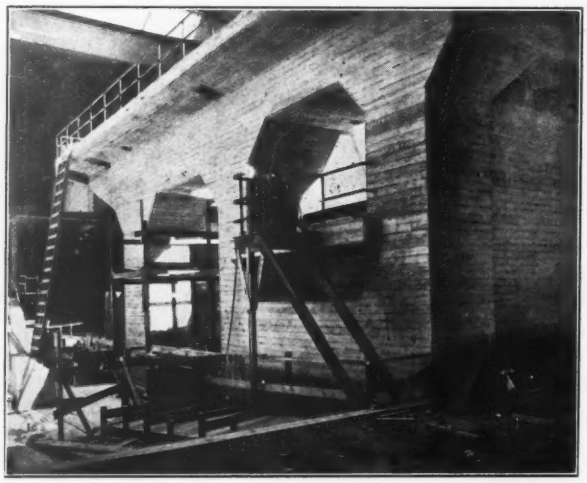


FIG. 6. THE TURBINE SHOWN IN FIG. 1 WILL REST ON THIS FOUNDATION

to operate the intercepting valve in the return line from the reheat boilers to the low-pressure element. Both elements are provided with an oil trip emergency overspeed governor.

The rotor for the high-pressure turbine is a nickel steel forging with integral wheels and couplings. That for the low-pressure turbine is an assembly of 17 forged wheels on a carbon-steel forged shaft. The buckets throughout are of chrome alloy, non-corrodible steel.

Generator stators are of built-up construction and are totally enclosed. The windings are of the transposed bar type, two conductors per slot. The rotors are solid steel forgings, milled out for the windings, which are concentric coils arranged around the periphery. The energy is generated at 12,000 v. star and each generator is supplied with differential relay protection. The neutral point of each generator is grounded through a 49,200-kv-a. reactor. The electrical characteristics of the two generators comprising the units are identical. Through the switching arrangements, the low-pressure generator may be operated without the high-pressure.

Cooling equipment employed on the generators is a closed air circulating system. Air is circulated through the generators and the cooling ducts by fans, integral with the rotor, at a rate of 125,000 c.f.m. The surface air cooler utilizes raw condenser water furnished by the pumps that supply the condensers. Fire protection for the generators will be furnished by a CO_2 gas system, arranged for remote control from the operating floor, in addition to the customary fusible links in the air ducts.

Condenser Equipment

Condensers are Foster Wheeler cylindrical, two-pass surface type, with boxes arranged in such a manner that half of each unit may be taken out of service for cleaning without removing the condenser from service. The tubes in these condensers are of Admiralty metal solidly rolled into Muntz metal tube sheets. It is intended that these tubes shall bow slightly under expansion and contraction with temperature changes. It is believed that this is the first installation on the Pacific Coast of such construction, although it has worked successfully in other installations. Each condenser has an area of 34,000 sq. ft., of which 500 sq. ft. are located in the external air cooler. Air is removed by means of a Foster Wheeler jet air pump of two stages.

Cooling water secured from the bay is pumped into the station by means of electrically driven centrifugal pumps. These pumps are located approximately one block away from Station A. Two Union Iron Works salt water pumps with a capacity of 65,000 gal. each driven by two 1250-hp. General Electric 3-phase, 2300-v., star-delta starting motors in addition to one 40,000-g.p.m. pump driven by one 700-hp., 2300-v. motor, furnish the cooling water. Each condenser requires 37,100 g.p.m. at full load, so that there is ample capacity in the salt water circulating system, not only for the present demands but for future growth. The salt water supply is particularly fortunate in that the discharge from the condensers is in a channel which is entirely separated from the bay intake.

As a preliminary to the enlargement and reconstruction now taking place, work was commenced about a year ago on the salt water channels. The entire intake, from the bay to the pump house, was rebuilt and this work constituted another interesting feature of the construction program. Various methods of tunneling and excavating were considered for this conduit, but the eventual decision was made in favor of precast interlocking concrete piles which were driven in place, forming the sides of the channel. A concrete floor was then laid and a precast concrete roof installed. The entire program was carried out without difficulties from water penetration, nor were the services of a diver required. The tunnel is 18 ft. in height and 10 ft. in width.

Conduits from the pump house to the station and the discharge lines from the station to the channel consist of two cast-iron pipe lines, one of 60-in. which was installed approximately a year ago, and the other of 30-in., installed several years ago.

Electrical Features

Output of the station is distributed to the various substations in San Francisco over 11-kv. feeders. Through feeders to Station H a tie with the 110,000-v. hydroelectric transmission system is secured. It is intended that in seasons of low stream flow, the output of Station A will be available to supplement the hydrogenerating system. In addition to the energy outgoing over 11-kv. feeders, a portion is transformed to 4-kv. and is supplied to nearby loads over 4-kv. feeders. Two

banks of 11-kv. to 4-kv. transformers, consisting of four 2500-kv-a. and three 1500-kv-a. supply this portion of the load. Station light and power is obtained through three 12,000/2300/230-v., three-phase transformers of 8384-kv-a. each. In addition, the old auxiliaries in the station are operated from a two-phase bank, which, when the four new units are in operation, will be removed.

The operating room of the plant will be located above the switching equipment on the fourth floor of the new switch house. Inasmuch as the operator will not be in sight of the turbine floor, a communication will be handled by the house telephone system. A Selsyn system, operated by the watt-meters on the main turbo-generators, will furnish load indication to the operators and attendants.

General Operating Conditions

The steam consumption of each unit at full load is 560,000 lb. per hr.; one reheat boiler will accordingly be sufficient to carry one unit at somewhat more than rated load. It is intended that the standard boiler will be held in reserve and will be used only for peak load operations. Output of the old station has never exceeded 240 kw-hr. per barrel of oil, or about 25,000 B.t.u. per kw-hr. It is believed that the new units will produce a kilowatt-hour at the rate of about 12,000 B.t.u., and the water rate at full load is expected to be under 9 lb. per kw-hr.

W. S. E. Elects Officers

At the 61st annual dinner and banquet of the Western Society of Engineers held at the Palmer House, Chicago, Ill., May 22nd, President Wm. S. Monroe reported the changes made in organization, the Washington Award given to Dr. Mortimer E. Cooley, the Alfred Noble Memorial Prize and the work of a number of special committees. These included the supervisory committee on Engineering of the Chicago World's Fair, the advisory committee to the Board of Education of Chicago, the Board of Commercial Arbitration of the Municipal Court of Chicago, the Structural Engineers Committee and the special committee which conducted tests on steel floor framing encased in concrete. He announced the election of officers of the Society as follows:

President: W. O. Kurtz, manager state area, Illinois Bell Tel. Co.

First vice-president, Frank D. Chase, president, Frank D. Chase, Inc.

Second vice-president, Harry B. Gear, assistant to vice-president, Commonwealth Edison Co.

Third vice-president, Charles C. Whittier, consulting engineer, Robert W. Hunt Co.

Treasurer, Leigh S. Keith, consulting engineer.

Trustees (one year), Geo. W. Hand, assistant to president C. & N. W. Ry. Co.; (two years), Chas. V. Weston, consulting engineer, Chicago Surface Lines; (three years), H. H. Field, secretary, electrification of steam railroads committee, National Electric Light Assn.

Past presidents who will serve on Board of Direction, Rufus W. Putnam, consulting engineer; John A. Garcia, consulting engineer; Wm. S. Monroe, president, Sargent & Lundy, Inc.

Chairmen of Sections:

Electrical Engineering Section, F. H. Lane, manager engineering and construction, Byllesby Engineering & Management Corp.

Hydraulic, Sanitary and Municipal Engineering Section, Clifford Older, president, Consoer, Older & Quinlan.

Bridge and Structural Engineering Section, H. H. Cosley, contract engineer, Mississippi Valley Structural Steel Co.

Mechanical Engineering Section, J. Hall Taylor, president, Taylor Forge & Pipe Works.

Railway Engineering Section, L. G. Curtis, chief engineer, B. & O. C. T. R.R.

Telephone, Telegraph and Radio Engineering Section, Gifford B. West, chief engineer state area, Illinois Bell Telephone Co.

Gas Engineering Section, K. B. Nagler, system development engineer, Peoples Gas Light & Coke Co.

Illuminating Engineering Section, H. J. Holmquest, secretary Committee on Physical Therapy, American Medical Association.

Maverick County Water Control and Improvement District No. 1 of Texas has just begun the construction of an irrigation and power project designed to serve 60,000 acres with water and to include a water power development of about 8000 hp. Contract for the canal construction has been awarded to Trinityfarm Construction Co., Dallas, Texas, and Bart Moore, Inc., San Antonio, Texas.

The contracts include the handling of about 14,000,000 cu. yd. of earthwork, 300,000 cu. yd. of rock and gravel and 25,000 cu. yd. of reinforced concrete. There will be placed about 2,000,000 sq. ft. of gunite lining.

There will be installed on the main canal about 10,000 linear feet of 10.5 ft. diameter reinforced concrete pipe. Construction material will consist entirely of earth, concrete and steel. The main canal is designed to carry 1500 sec. ft. of water.

The District will sell the water to the Central Power & Light Co. of San Antonio, a subsidiary of the Insull interests. The power company will install the power plant and operate it. This plant will operate under an 87-ft. static head. As construction on the canal system has not advanced far the power company has not yet begun construction of its plant. E. B. Neiswanger, San Antonio, Texas, is president of the Central Power & Light Co.

According to an interesting story which appeared in the New York World, S. W. Royce, manager of the Hotel Huntington, Pasadena, California, discovered that he could use electric flood lights to put a stop to the disturbance caused by bull frogs in the hotel lily ponds. It seems that he tried ducks, offered prizes to children for every frog captured dead or alive, and hired rifle shooters. After all known methods had failed, he purchased all the books on the habits of frogs he could find and soon became an authority. Learning that frogs sing only under the cover of darkness, he provided for the illumination of the lily ponds by electric flood lights. Now the frogs, baffled by science, sit dumb, vainly awaiting the curtain of darkness while the guests sleep.

What Method Should be Used to Give a Fair

Comparison of Steam Station Performance

Since steam pressures, temperatures and operating cycles have become so diversified no suitable expression for station performance has been available. Professor Christie proposes an expression which includes two constants and the capacity factor. One constant is a function of the station operating cycles, the other, depends upon the non-productive or no load heat imput. For thirty years Professor Christie has played an enviable part in the design, construction, erection and operation of power plants and his suggestion deserves extended discussion and supporting data to bring out the effects of the other variables mentioned.

By Professor A. G. Christie
Johns Hopkins University

AN ENGINEER, meeting another engineer who has charge of the operation of a large central station, generally asks, "What are you doing in your plant?" The usual reply is, "Last month we averaged —— B.t.u. per kw-hr." This figure may represent good performance to a man with a plant having low steam pressure, superheat and load factor, but may seem high in comparison with a base load plant with 1200 lb. steam pressure. The mere statement, "—— B.t.u. per kw-hr.," suggests nothing in regard to the steam cycle performance of the plant and gives no indication of the effect of capacity factor on station efficiency. One should know something of these factors to appraise correctly the performance of this particular station. Yet at present the accepted basis for the comparison of steam station performance in America is "—— B.t.u. per kw-hr." The following paragraphs will outline a proposed method of stating steam station performance, which gives consideration both to the actual steam cycle of the plant and to its capacity factor in the hope that this may start a discussion of methods for stating steam station performance which are more logical and informative than simply "—— B.t.u. per kw-hr."

Let us first examine other methods in use to express steam plant performances. British engineers use "thermal efficiency" as such a measure. This efficiency is found by dividing the heat equivalent of 1 kw-hr. (3413 B.t.u.) by the B.t.u. per kw-hr. in the fuel supplied. This expression has no advantages over the American measure of "—— B.t.u. per kw-hr." which actually constitutes the denominator of the equation.

Parsons Line Does Not Consider Capacity Factor

Various British and continental engineers plot a curve, sometimes called the "Parsons Line," between pounds of coal burned per shift and kw-hr. output per shift. An example of such a curve is shown in Fig. 1 which is taken from an article on the Willesden Power Station of the London Power Co., London, England appearing in The Engineer, London, Mar. 22, 1929. The equation for such a curve is found and this equation is used to express the performance of the station. Thus in Fig. 1 the performance of the Willesden Station for the month of Feb. 1928, is expressed as

$$C = 29{,}000 + 1.48$$

where C = total pounds of coal burned per 8 hr. shift, and K = kw.hr. output per shift. Interpreting this equation, 29,000 lb. of coal are burned per 8 hr. shift to

---

Professor A. G. Christie, Professor of Mechanical Engineering, Johns Hopkins University, Baltimore, Md., was graduated from the University of Toronto in 1901. He was engaged from then until 1904 with Westinghouse Machine Company, East Pittsburgh, Pa., on their early steam turbine developments, and tested and erected many of their earliest machines. Then followed a year as instructor at Cornell University.

In 1905, Professor Christie went with Allis-Chalmers Mfg. Co. to take charge of the erection and operation of their first steam turbines and later became assistant superintendent of construction with that company. In 1907, he became mechanical engineer for the Western Canada Cement and Coal Co. at Exshaw, Alberta, where he completed their plant and operated until 1909.

In 1909, he was appointed Assistant Professor of Steam and Gas Engineering at the University of Wisconsin and took over their experimental laboratories and research work. In 1914, he became Associate Professor of Mechanical Engineering at the Johns Hopkins University and later was appointed Full Professor.

Ever since Professor Christie entered college work, he has been very active during his summer vacations in actual commercial engineering. He spent the summers of 1910 and 1913 in Europe investigating steam turbine and internal combustion engine developments. He also spent several summers in Western Canada on the design and construction of the various plants. During the war, he spent one summer with the Navy Department in Washington and another in the shipyards at Hog Island.

He was associated with Stone & Webster and later with McClellan and Junkersfeld on the design of several of the important American power plants including Hartford Electric; Cahokia and Ashley St. at St. Louis; Lakeshore and Avon at Cleveland; International Paper in Quebec, and India Basin at San Francisco. He served for several years as consulting engineer for the Hydro Electric Power Commission of Ontario. The summers of 1927 and 1928 were spent in England on consulting work for British interests. Last summer he served on a government commission for the Province of Alberta, Canada, studying certain special power problems of that district.

Professor Christie has been actively identified with the work of the Power Division, A.S.M.E., and has served as a member of the Prime Movers' Committee, N.E.L.A., for many years.

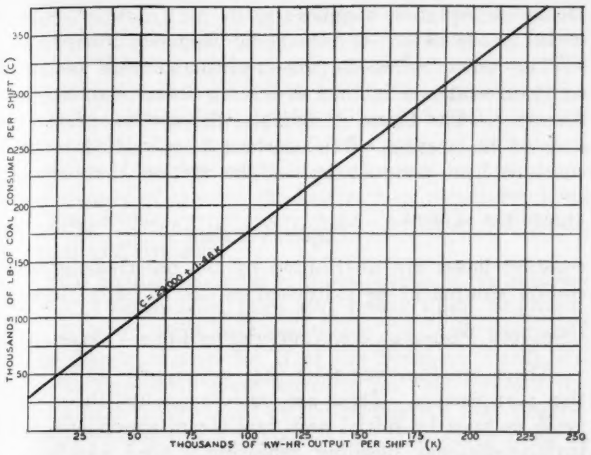


FIG. 1. PARSONS LINE AS AN INDEX OF STATION PERFORMANCE. DATA REFERS TO WILLESDEN POWER STATION, LONDON

provide for station standby, starting, banking, and no load losses, and for auxiliary power. The amount of this term in station performance is therefore a measure of non-productive requirements of the plant. The incremental amount of 1.48 lb. that is burned per kw-hr. is probably connected in some way with the particular operating cycle of the plant.

This method is a step in advance for it seeks to separate productive from non-productive fuel consumption. It is, however, open to criticism. The heat values of the coal burned in different stations usually vary widely and "pounds of coal" alone is therefore an unsatisfactory basis for comparison. This straight line relation for pounds of coal suggests that a similar relation should exist between total B.t.u. in the fuel consumed and kw-hr. output. The equation indicates no connection between its terms and the capacity factor of the station.

Use of Capacity Factor Has Advantages

One will ask why capacity factors are stressed in connection with steam station performance and why load factors are not used. The term "capacity factor" as here used, is the ratio of the station output in kw-hr. for a given period, to the product of the rated capacity of the generators in the station in kilowatts and the total number of hours in the given period. Now suppose that a station were run for the first half of the year at 80 per cent capacity factor and for the remainder of the year at 40 per cent capacity factor. The station performance in B.t.u. per kw-hr. for the first period might be 8 per cent less than the performance for the second half year. Let us next assume that instead of a single station, these figures referred to two separate stations of identical design and equipment, with similar methods of operation and operated with the same skill and finally both using the same coal. Let one operate with 80 per cent annual capacity factor and the other with 40 per cent as before. The fact that the annual performance of the one with 40 per cent capacity factor as measured by B.t.u. per kw-hr. is 8 per cent more than the other with 80 per cent capacity factor would lead to the casual inference that the station with 40 per cent capacity factor was either of poorer design or was operated less efficiently than the other. But the assumption has been made that both stations are identical in design and equipment, burn the same fuel and are operated on the same cycle with the same degree of skill; therefore the variation of 8 per cent in performance must be evidently due to the difference in capacity factors. An ideal expression of station performance should therefore consider capacity factor as one of its elements.

Load factor is defined as the ratio of average load over the period of a day, week, month, or year, to the maximum load that exists for a certain number of minutes (frequently 20 minutes) during the given period under consideration. Load factors may be the same on different days although the plant capacity needed to carry the maximum load may vary widely on these days. While the load factor is useful for many purposes, it bears no relation to the size or power demands of the auxiliary equipment, nor to the no-load losses of the main turbo-generators and boilers. The variable factor in station performance is largely dependent on these auxiliary and no-load heat requirements. Auxiliary power and no-load losses are in general related to plant capacity and operating results seem to verify this conclusion. Hence, for purposes of comparing station performance, "capacity factor" appears to be preferable to "load factor."

Station performance may be represented by an input-output curve. The input can be expressed as the total B.t.u. in the fuel burned during a given period, say a day or week, while the output is the net kw-hr. leaving the station during the same period. Such a curve is shown in Fig. 2 and has been found to be practically a straight line for steam power plants containing equipment of a homogeneous character. Objection has been raised that, from a theoretical standpoint, the input-output line should not be straight since the boiler input-output lines curve at high ratings; the Willans line of the main turbo-generators also curves; and the

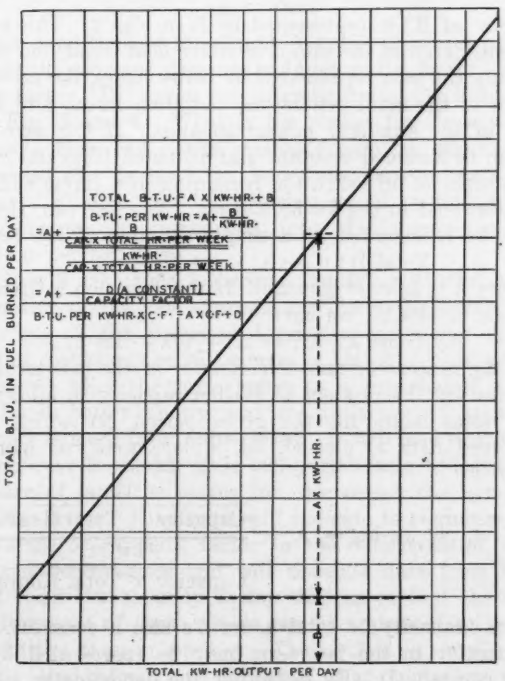

TOTAL B.T.U. = A X KW-HR. + B
B.T.U. PER KW-HR. = A + B / KW-HR.
= A + B / CAP. X TOTAL HR. PER WEEK / KW-HR. / CAP. X TOTAL HR. PER WEEK
= A + (A CONSTANT) / CAPACITY FACTOR
B.T.U. PER KW-HR. = A X C.F. = A X C.F. + D
TOTAL B.T.U. IN FUEL BURNED PER DAY
= A KW-HR.
B
D
TOTAL KW-HR. OUTPUT PER DAY

FIG. 2. INPUT-OUTPUT CURVE SHOWING THE NON-PRODUCTIVE OR NO LOAD HEAT INPUT AS B

performance curves of certain auxiliaries are not straight. One would therefore be led to assume that their combination in the input-output line of a station could not be straight. A study of the actual input-output lines of power stations indicates that these variables seem to neutralize one another for it appears that while actual performance data, when plotted, do show some scattering, they can, for all practical purposes, be represented for a given station capacity by a straight line drawn as a mean through the plotted points. Individual performances may lie above and below this mean line due to variable influences in plant operation. A further study of the subject may reveal some variables that have not been given due consideration and which may alter slightly the form of the line or may require station performance to be represented by a plane in three dimensions.

It will be noted that this input-output curve, when projected, cuts the input ordinate at zero output at an

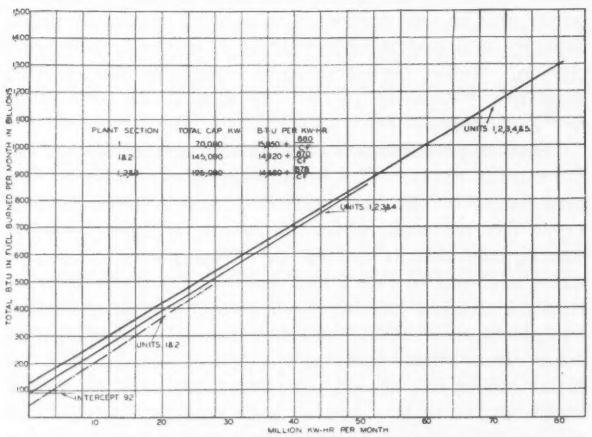


FIG. 3. INPUT-OUTPUT CURVES FOR THREE PHASES OF A LARGE COAL FIRED CENTRAL STATION

amount of B.t.u. represented by B in Fig. 2. This may be considered as the non-productive heat input and constitutes the heat represented by boiler losses, the no-load losses of the main generators, radiation losses, and certain of the auxiliary power demands. If this amount B can be assumed constant and deducted from the total heat input at all loads, the remaining heat input will be proportional to the kw-hr. output. The line can, therefore, be represented by a simple equation of the form,

$$\text{Total B.t.u.} = A \times \text{kw-hr.} + B$$

Where A is another constant. If this equation is divided by the net kw.hr. we have:

$$\text{B.t.u. per kw-hr.} = A + (B \div \text{kw-hr.})$$

Let the numerator and denominator of the last term be divided by the product of station capacity in kilowatts and total hours for the given period for which the observed data is plotted, i.e. a day, week, or month. Then—

$$\text{B.t.u. per kw-hr.} = A + \frac{\dfrac{B}{\text{Capacity} \times \text{Total Hours}}}{\dfrac{\text{kw-hr.}}{\text{Capacity} \times \text{Total Hours}}}$$

Since (capacity $\times$ total hours) is also a constant, the numerator in the last term may be represented by a new constant D. By definition, the denominator is the capacity factor if the station for the given period.

Hence the equation becomes:

$$\text{B.t.u. per kw-hr.} = A + (D \div \text{Capacity Factor})$$

The writer proposes the right-hand side of this equation as a new method of stating steam station performance. The figure A indicates the cyclical performance of the station. The constant D is related to the constant heat consumption of the station that occurs regardless of load. $\dfrac{D}{\text{Capacity Factor}}$ shows how he constant losses are distributed by the use made of the station equipment as expressed by its capacity factor.

Station Performance Affected by Four Variables

There are four variables that apparently affect station performance. These are, rated capacity; the steam cycle as fixed by initial and final steam conditions, the turbine efficiency, bleeding, reheating if used, and boiler plant efficiency; capacity factor; and cooling water temperatures. A study of the proposed equation indicates that the term $\dfrac{D}{\text{Capacity Factor}}$ covers variables due to rated capacity and capacity factor. The term A states the steam cycle performance of the station equipment. Variations in cooling water temperature influence the steam cycle because water rates of the main units are increased or decreased by changes in vacuum. The non-productive factor D, is also affected to some extent since more auxiliary power is needed when steam demands are increased due to low vacuum as a result of warm cooling water. An additional term should possibly be added to the question to care for the influence of variations in cooling water temperature. The station input-output might then be plotted as a wedge-shaped plane in three dimensions. A study by the writer of such data as were available did not reveal any figures that would be of value in developing such an expression or diagram, for variations in station performance from other operating causes made it impossible to properly evaluate the influence of the cooling water. Possibly careful mathematical analysis of other data might reveal a third term dependent on cooling water temperature. Until such a factor for cooling water temperature can be found, the writer proposes the simple form of expression for station performance as

$$\text{Steam cycle performance} + \frac{\text{constant}}{\text{Capacity Factor}}$$

This form of expression can be applied to best advantage in a station with equipment of a similar size and type where operating cycles, auxiliary demands and no-load losses are of the same nature. A plant with equipment of different sizes and characteristics, with both steam and motor-driven auxiliaries, and with boiler plant of different sizes and types would obviously give varying station performance for a given output depending upon what particular combination of equipment was used to secure that output. Hence this equation is essentially more applicable to homogeneous stations.

An example of input-output curves is given in Fig. 3, which shows the curves for three stages in the development of one of the large central stations in the United States. Each stage was characterized by certain changes in the steam plant cycle and in auxiliary power consumption. A notable fact is that the factor D is

nearly constant for all three stages of development. It has been stated that this factor D for American steam stations burning coal will vary from 850 to 1000. The writer was shown some data on British stations which were characterized by a similarly small variation in the value of D. This constancy of the value of D suggests the need of further analysis of its constituent elements and a study of the non-productive heat requirements as a major element in the possible bettering of steam station performance.

Still another example of input-output curve analysis is Fig. 4 taken from page 407, Power Plant Engineering, April 1, 1929, and represents the performance of Long Beach Station No. 3 of the Southern California Edison Co. This plant operates on fuel oil and the curves have been plotted on the assumption that a barrel of fuel oil contains 6,250,000 B.t.u. The curve plots as a straight line. The heat consumption at 100 per cent capacity factor is 30.9375 billion B.t.u., and at no load 1.9531 billion B.t.u. The station performance can therefore be stated as 12,077 + (814 ÷ C.F.) B.t.u. per kw-hr. where C.F. is equal to the capacity factor. It is worth noting that the D factor for this oil-fired station is lower than those of Fig. 3 which represents a coal-fired plant. This may be due to the lesser number of auxiliaries required in the oil-fired boiler plant and to lower starting and stand-by losses.

This proposed method of expressing station performance was presented by the writer to the Prime Movers Committee, N.E.L.A. at one of their meetings last year. At that time an expression was proposed with load factor in place of capacity factor. For reasons stated above, it now appears that the use of capacity factor is preferable. This plant has started much discussion since its presentation, but new data are not available for present publication. Several engineers have offered modifications of the proposed formula; however, as previously stated, variations in plant operation obscure the influence of the third factor, i.e. cooling water temperature, to such an extent that no co-relation has been established between this temperature and station performance in the data analyzed to date. The possibility of deriving a more satisfactory expression than the present statement of "—— B.t.u. per kw-hr." warrants further study of all available data to establish proper co-relations of all factors.

Objection has been raised that this form of expression is too general to enable plant engineers to watch for variables in station operation and that other methods of evaluating losses can secure better station control. This is quite true for day to day performance. The proposed expression is not intended as an exact check on such operation but as a general form to express average performance over an extended period, say for a year, and furthermore to serve for the purpose of comparing various stations rather than as a measure of individual day-to-day results. It should not, therefore, be used as a close daily check on the operating man.

One will remark that the proposed expression for station performance, viz:

$$\text{Steam cycle performance (A)} + \frac{\text{Constant (D)}}{\text{Capacity Factor (C.F.)}}$$

is no more illuminating that the older expression "—— B.t.u. per kw-hr." This is probably true at the moment for engineers have not been thinking in terms of the steam cycle performance of their plants. They do not realize the size or significance of the constant dependent on the non-productive heat input nor have they seriously compared this factor in different plants to discover how it may vary and from what causes. Finally they have been accustomed to think of station operation in terms of load factors rather than in the more logical terms of capacity factors.

This method of expressing station performance raises some interesting questions and new problems. In what manner is the factor expressing the steam cycle performance related to the results of theoretical heat balance studies for the particular station? Does this factor include any auxiliary demands that vary with load, such for instance, as power to boiler feed pump above no load power, or similar demands above no load of the forced and induced draft fans? How can the factor for steam cycle performance be decreased with the given steam conditions of the plant? What is the exact nature of all the constant elements included in the factor "D"? The factor "D" varies for different stations as indicated by Fig. 3 and 4. What is the reason for these variations? How can power station design be modified to decrease this factor "D" and thus improve performance? Finally, how can variations in cooling water temperature be introduced into this expression for station performance?

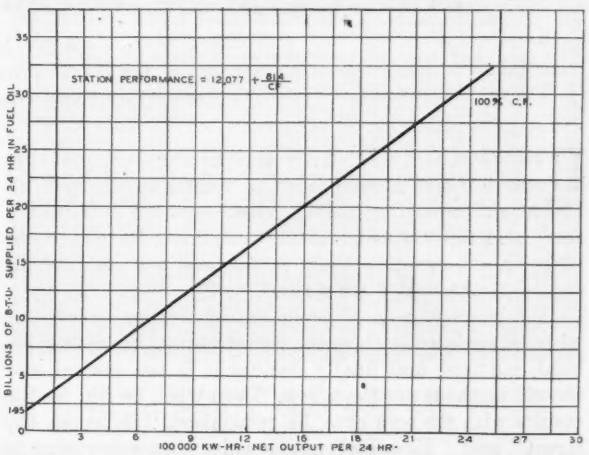


FIG. 4. INPUT-OUTPUT CURVES FOR LONG BEACH NO. 3 STATION

It will take time to become familiar with the interpretation of the new expression. The writer holds that the use of the proposed form for comparing steam station performance will convey a better idea of actual efficiency when the performance to be expected of steam cycles is better known and the influence of capacity factors is more fully appreciated. It will lead to studies to improve the steam cycle and particularly to learn the nature of, and the means for, decreasing the non-productive losses. Finally, it will indicate to engineers the influence of capacity factor in the determination of a station performance and will co-relate data from high and from low capacity factor stations so that the true performance of these plants can be appraised to better advantage than at present. The method is simple and easily understood. It is hoped that engineers with stations of the same equipment throughout will try out this method and will discuss its possibilities.

ADDISON W. LEE, JR., general superintendent of Louisville Gas & Electric Co., was born in Louisville, Ky., July 31, 1885. He was graduated from Rose Polytechnic Institute, Terre Haute, Indiana, in 1906 as an electrical engineer. For a year, he was with the Chicago and Eastern Illinois Railroad and in 1907 was employed by the Louisville Lighting Co. He remained with the Louisville Gas & Electric Co. when it took over the lighting company.

Mr. Lee is chairman of the Louisville and Jefferson County Air Board, which has charge of Bowman Field; is Governor for Kentucky of the National Aero Association; is a past president of the Engineers and Architects Club of Louisville; and is a member of American Institute of Electrical Engineers, American Society of Mechanical Engineers, American Engineering Council, Louisville Board of Trade, Louisville Boat Club, Big Springs Golf Club, Crescent Hill Golf Club and he is a Colonel on the staff of Governor Sampson of Kentucky.

The Air Map Versus the Missouri Mule

AIR MAPS CAN BE MADE FOR FROM $10 TO $35 A MILE AND THIS ARTICLE SHOWS HOW EASILY AND EFFECTIVELY THEY CAN BE USED

BEING AN ENGINEER and having been one for more years than I care to remember, I have no hesitation in saying that a cross between "Balaam's Ass" and the "Missouri Mule" could not be more stubborn or conservative than is the average engineer in regard to the use of air maps.

He bitterly resents being called unprogressive but when something brand-new comes along, he shakes his head, mutters, and finally decides it is too radical and the old methods are the safest. Even when he can see the results with his own eyes, he remembers "Hermann the Great" and "Houdini" and decides that everything is not as it seems,—so why take a chance?

In all justice to the engineer, however, it must be said that when he is convinced, he is convinced "all over," therefore our endeavor in this article will be to prove to him the usefulness of such maps—and their very great economy.

This article is confined principally to actual uses to which air maps can be put, as it is thought that the profession has been sufficiently informed as to costs and methods employed in the actual making.

FIG. 1. THE ORIGINAL AERIAL PRINTS LOOK LIKE THIS

Also because generalization is always open to criticism, we are using a specific case, an electric transmission line, and will attempt to show, step by step, the course actually followed in the survey.

The line in question is a 132,000-v. transmission line, between two midwestern cities about 90 mi. apart, but the general procedure outlined may be followed for surveys of gas lines, railroads or rivers.

For the purposes of convenience and for ease in outlining the procedure, the operations are subdivided under the following heads.

1. Preliminary selection of route.
2. Actual making of the map.
3. Tentative location and preliminary right of way data.
4. Preliminary location of towers and beginning rights of way purchases.
5. Profile.
6. Staking towers and beginning of construction.

Just as this article is completed, I am informed that the engineer in charge of delivering material on the job has just made up a map on which he has marked out highways, farm roads and trails, by means of which he expects to save enough on hauling charges to pay the cost of the map.

1. PRELIMINARY SELECTION OF ROUTE

Territory between the two cities was poorly mapped; in fact, the standard Rand-McNally seemed about the best available, therefore these were used for preliminary discussion. One city being north of the Ohio River and one south, three possible routes were available. The three routes were then driven as closely as possible by automobile, giving all the engineers concerned an approximate idea of the topography and the type of roads to be met with in delivering materials on the job.

Before making the map, the third and final step was an aerial inspection of the routes, made by a joint party of engineers in a tri-motored Ford plane. Sev-

eral engineers also made individual trips by open plane. The pilot who was to take the photographs was carried on practically every trip in order to familiarize himself with the land marks and facilitate flying a straight course when the final map was started.

In spite of our enthusiasm, let me here sound a note of warning.

Have the photography done by a reliable and competent outfit and then check up their work as follows:

a. Unless accurate bench marks throughout the territory are available, see that accurately calibrated recording barometers are used in the plane and on the ground in order that enlarging to scale may be done correctly.

b. Assure yourself that such enlarging is carefully done in order to compensate for tilt of the plant and for variation in flying altitude.

c. Be sure only the central parts of the individual films are used in making the mosaic in order to eliminate the angular distortion of the lens at the edge of the original print.

When and if these precautions are taken, you can be certain that your mosaic will have a maximum error less than one and one-half per cent when no bench marks are available and less than one-half per cent when reliable bench marks are available.

2. Actual Making of the Map

With these preliminary details out of the way, the route was flown and photographs similar to Fig. 1 were secured.

These were made into a mosaic by the usual method, rephotographed to scale and copies of the completed map were furnished the engineers and right of way men. The most generally used forms of the final map are shown in Fig. 2, used in the office, and Fig. 3, used in the field. Enlargements secured from the original mosaic were numbered and their locations marked on an index map. Individual prints of these enlargements were also made and given to the right of way men for their preliminary activities.

3. Tentative Location and Preliminary Right of Way Data

Immediately upon receipt of the roll map, shown in Fig. 2, it was laid out on long tables and a heavy cord was tightly stretched between points representing each end of the line. The territory traversed by this cord was then minutely examined on the map and wherever the route was obviously poor, the cord was bent just enough to miss obstacles and was fastened into its new position by means of thumb tacks.

To those familiar with the use of air maps, the hillsides, precipitous bluffs and swampy lands can usually be detected from a plain photograph but in order to make doubly sure that these natural hazards were recognized, a separate set of prints was made up and viewed through a stereoscope. It will be obvious to anyone examining the illustrations accompanying this article that woods, cultivated lands, creeks and roads are conspicuous.

While the preceding study was being made, right of way men were going to the county seats and were securing, by means of farm maps, county records, oldest citizens, etc., the names of owners of the farms through which the line would probably pass. Figures 3 and 4 both show typical examples of the type of work done by these parties.

In this connection, a peculiar situation arose. Not a single right of way man on the job had ever used air maps previously and these men, like the engineers, were so accustomed to pieces of blue paper with white lines on them and figures representing rods or feet that for a time they were all at sea. As a matter of fact, they really seemed to prefer a description giving metes and bounds, which, when laid out by instrument would not close, to an actual picture of the farm under consideration. We would, therefore, like to remark in passing that every right of way man on the job became an air map enthusiast and that the job was done more quickly and more cheaply than any of which we have record.

Immediately upon the completion of the location work in the office, two experienced transmission line construction engineers drove and walked the entire

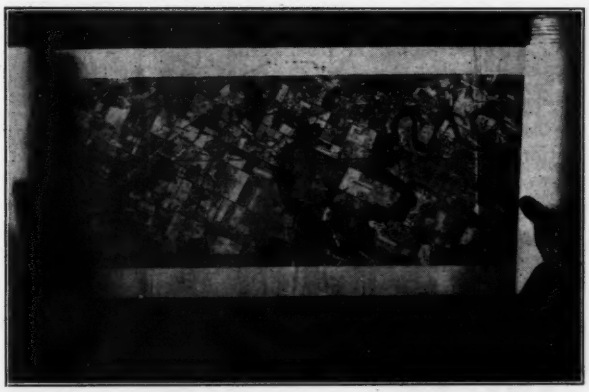


FIG. 2. INDIVIDUAL PRINTS ARE CAREFULLY MOUNTED ON CLOTH TO FORM A LONG ROLL MAP. A STRING STRETCHED FROM END TO END OF THE MAP SHOWED THE SHORTEST ROUTE AND SERVED AS A BASIS FOR THE FINAL LOCATION

route and made such additional changes as were necessary to dodge obstacles overlooked in using the photographic map. In this particular case, the final route as actually chosen deviated from the route selected in the office by only a few hundred feet in one creek bottom.

It was remarkable how quickly the enthusiasm of these engineers mounted as they realized that every land mark was shown on the photograph. They learned to use dead trees, cross roads, farm drains, gully washes and residences as land marks and paved the way in their one trip for the location of the towers. Upon the completion of this section of the work, the work map assumed the appearance shown in Figs. 3 and 4.

4. Preliminary Location of Towers and Beginning Rights of Way Purchases

While the work described above has been going on, design engineers used the map sections as they were marked and chose a design span, placing everything in readiness for preliminary location of the towers.

Using this data and sticking as closely to the design span as seemed possible, the preliminary location of each tower was spotted on the air map ready for use by the field party making the final locations.

In the meantime, the right of way men obtained

FIG. 3. SEPARATE PRINTS OF THIS KIND WITH THE LAND OWNERS' NAMES, ARE USED BY THE RIGHT-OF-WAY MEN

lawyers in one or more towns and made connections with farmers along the line, being prepared at the zero hour to start obtaining rights of way on the forms shown in Fig. 7.

As will be noted, this form is really a recordable option on the right of way, and payments are divided between tower locations, rods of right of way, and damages. This form, provided to meet the peculiar needs of the air map, proved to be very successful and the rights of way costs were unusually low.

The plan followed contemplated the use of several parties starting simultaneously from different points and resulted in securing about three-fourths of the rights of way within the first few days.

5. Profile

Immediately upon receipt of the map marked with preliminary location of towers, the field party ran a profile of the line. The field party consisted of two men, shown in Fig. 5, and their instruments were the field map and altimeter, shown in Fig. 4. The profile thus secured is shown in Fig. 6. Copies of this profile were given the design engineers and the construction engineers in order to plot the final locations of the towers.

Attention is here called to the fact that in a project of this type the relative elevation of the tower and center of the span and the surface of the ground are really the vital points, the main idea being to assure reasonably close adherence to the design span and sufficient clearance with maximum sag. The actual elevation of the hilltops, hollows or line above sea level is of minor importance. The altimeter method is, therefore, sufficiently accurate and is by far the least expensive.

6. Staking Towers and Beginning of Construction

Carrying with them the profile, as shown in Fig. 6, and the route, as shown in Figs. 3 and 4, the field party, consisting of a design engineer and construction engineer, traversed the entire line staking each tower and marking its location correctly on the map.

It must be remembered that during these last operations, the right of way men are still at work and have daily communicated with the construction engineer so that the entire project will be ready for the construction work with as few gaps as possible.

It is needless to point out that where difficulties are met, such as in the case of a holdout or holdup, the line can be relocated far more easily and intelligently by use of the air map than if additional instrument surveys had to be made.

Copies of the final map are now given to the construction superintendent and are used by him in the selection of haul roads, camp sites and railroad delivery points.

Check Survey

In view of the fact that the air map for this particular project was not of the precise type, in other words its accuracy was supposed to fit the type of job to be done, it was decided as a matter of interest and information to run a check survey along portions of the route and to check the entire work done with the altimeter. The method used was to scale a certain distance on the air map, then by means of chain and transit to determine the actual distance and compare the two. A profile of the entire line was run by means of the ordinary instruments and this was compared with the profile shown in Fig. 6.

The results of this check survey showed errors in distances of one mile up to 1.4 per cent, the distance scaled from the blueprint being shorter than the distance actually chained. Over greater distances of 5 and 10 mi., the error became less, being slightly over one per cent.

In preparing the final maps, due consideration being given to the accuracy desired, it was thought unnecessary to take into account shrinkage of the prints upon drying and to this shrinkage is due a great part of the one per cent error in length.

But, and do not overlook this but, it must not be forgotten that all that is now necessary to make this map accurate within less than one-half of one per cent is to make a one per cent change in the scale marked on the finished copies and this can always be done without expense of a check survey where bench marks are present.

Altimeter measurements naturally showed a greater deviation, the maximum error being about three per cent in differences of elevations up to 100 ft. and 4 per cent in differences up to 200 ft. Once again, however, it must be noted that no recording barometer was used

FIG. 4. A COMPLETE MAP IN BOOK FORM AND AN ALTIMETER CONSTITUTE THE EQUIPMENT OF A CREW ON THE FINAL SURVEY

FIG. 5. A FIELD PARTY OF THE SURVEY CREW CONSISTS OF TWO MEN

in connection with the altimeter and that readings were taken to the nearest two feet.

Side Lights

May we conclude this with a few general comments on air mapping and this particular survey?

A survey crew may make mistakes that will never be caught but the air map, once the correct scale is established, necessarily shows everything in its proper relation. The lens of an aerial camera has a fixed focal length and is just as much an instrument of precision as is the transit. Either of the two may be misused and inaccuracies will result.

With proper use of the camera, however, no glaring or vital mistakes can be made. One or two examples come to mind. In one case, a highway survey was made by air and it was found that a county road was shown on the Highway Commission's existing map on the wrong side of a railroad for a considerable distance. In the second case, a carefully prepared and expensive map of a large city showed two important streets intersecting a third street at exactly the same point. The air map showed that the two streets intersected the third street at points some 30 ft. apart. We will almost guarantee to find similar inaccuracies in any other existing map of a large area.

Many cases have occurred where the work of the right of way man was facilitated by giving the farmer an enlarged photograph of his farm.

The number of men constituting right of way or survey parties is reduced to an absolute minimum.

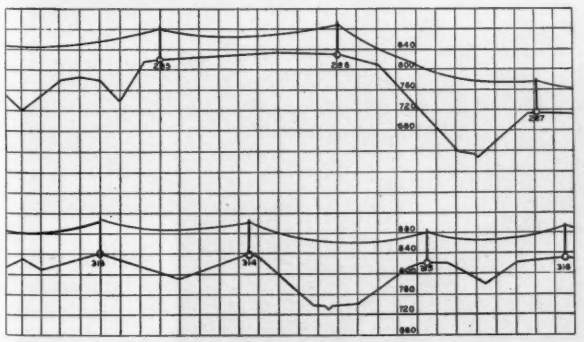


FIG. 6. FINAL PROFILE AND TOWER LOCATION, THE ONLY DATA NOT RECORDED DIRECTLY ON THE AERIAL MAP

Maximum number of right of way men used on the project described above was seven and they were told by men unfamiliar with the use of air maps that the job would last from three to six months. As a matter of fact the majority of them were released in less than one month and before the end of the second month only two men remained.

Further to emphasize this point, it is notable that in four weeks, 220 grants out of a total of 235 were secured.

Permanent records secured by the companies participating will be absolutely complete. When the towers are numbered, it will not be necessary for the operating superintendent to go into the field at every indication of trouble, but he will be able to size up the general situation by glancing at the affected tower or span on the air map.

For and in consideration of Five Dollars ($5.00) cash in hand paid, the receipt of which is hereby acknowledged, I / we

grantor hereby convey and warrant to D. S. KEENAN, grantee, his successors, heirs and assigns, a right of way fifty (50) feet on each side of a center line to be designated by the grantee, his successors, heirs or assigns (said center line to be evidenced by the center line of the transmission line herein referred to) to construct, reconstruct, operate, maintain and remove lines for the transmission of electrical energy, including the necessary towers, poles, wires, guys, stubs and other fixtures and appurtenances over, across and upon the lands of the grantor situated in

.Township, County, State of

.Section.

with the right of ingress and egress to and from the same, and with the further right to cut down, remove or trim any trees, both within and without said right of way, that may interfere with or endanger said line or its maintenance or operations.

The said grantor .. successors, heirs or assigns, fully to use and enjoy the said premises except for the purposes herein granted to the said grantee, his successors, heirs and assigns.

As a further consideration the said grantee, his successors, heirs and assigns, agree to pay to the said grantor successors, heirs and assigns, the sum of

for each tower constructed hereunder and cents per rod for each rod of right of way, and for all damages caused by the original construction of said line.

The said grantee successors, heirs or assigns further agree to pay for all damage to buildings, growing crops and fences caused by the operation, maintenance or reconstruction or removal of said transmission lines.

This grant shall be deemed to be abandoned and null and void unless the construction of said line is begun within twelve months from date.

Title of the grantor to the said premises was acquired by deed from and recorded in Book Page in the office of County, State of

WITNESS the signature and seal of the grantor this day of 1930

Witness (Seal)

FIG. 7. AN ORIGINAL RIGHT-OF-WAY BLANK. ANOTHER PAGE OF THE FORM CONSISTS OF THE USUAL NOTARY'S SEAL AND DATA FOR FILING AND INDEXING

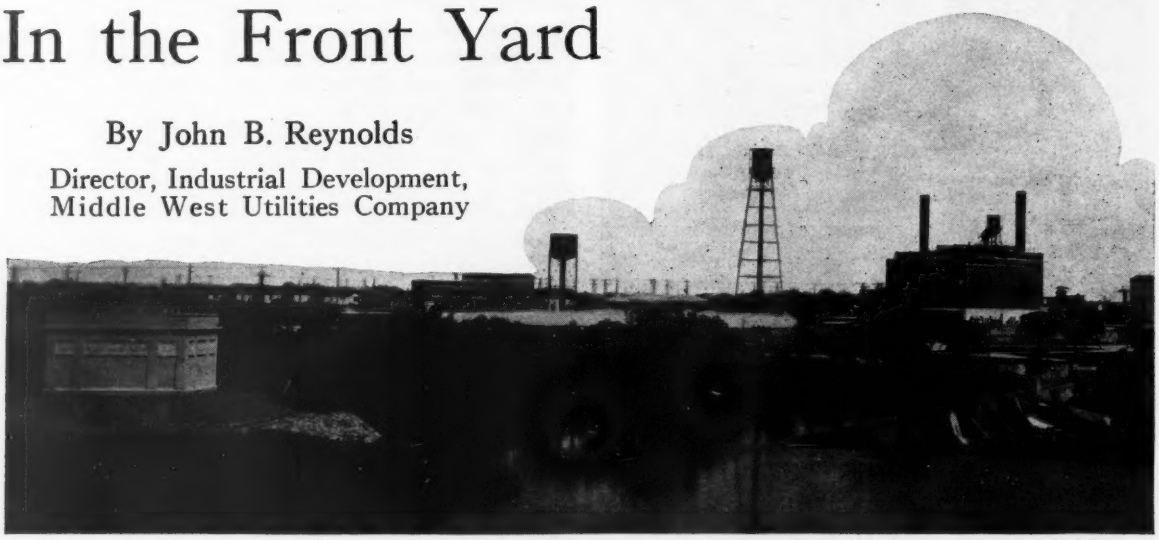
Air maps can be made for from $10 to $35 per mi. according to the accuracy desired and an aerial topographical survey, with 10-ft. contours, has been completed at a cost of $70 per sq. mi.

Generations of engineers have become familiar with the standard type of map which attempts to show all conditions by means of straight lines, wiggly lines and symbols and it is difficult for them to adjust themselves to an entirely new type of map. It is also difficult for them to become familiar with the meaning of the lights and shadows shown on the air map. But the more they study it and the more they use it, invariably the better they like it.

Costs will be reduced as use increases and new uses will constantly be found.

PUTTING THE POWER COMPANY In the Front Yard

By John B. Reynolds
Director, Industrial Development,
Middle West Utilities Company



CONCHO GENERATING STATION AT SAN ANGELO

BECAUSE OF THEIR blunt vision, in abandoning their properties to what they regarded as the inevitable squalor of their setting, utility and railroad executives have been responsible for a considerable part of the grief and ill-feeling which these companies have accumulated in the past. Set almost invariably on the water levels of the cities served, these properties have been afflicted with the back-yard stigma which American cities in the past attached to their water fronts.

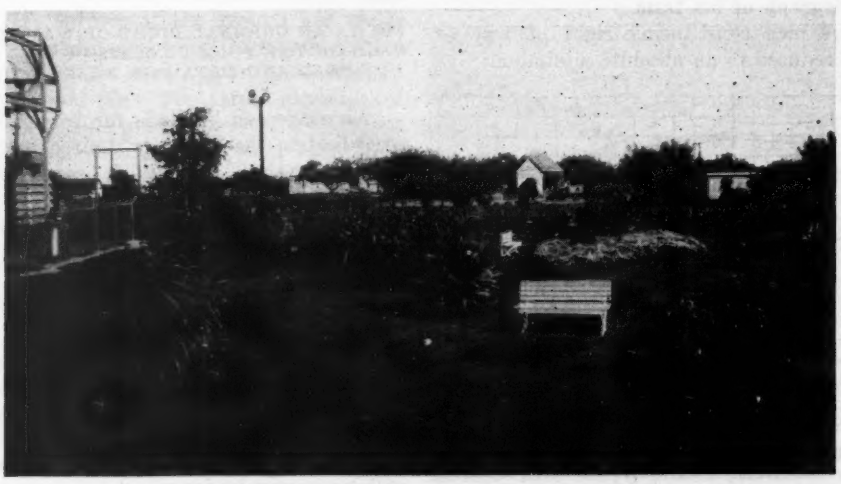
The mental conception of most people of railroads and utility companies includes smoke-hung, sooty buildings, surrounded by piles of cinders, coal and junk, and facing an odorous expanse of filthy water.

It is natural that people should so regard their service companies, for the companies themselves have been too much inclined to accept the setting as a necessary adjunct of their business.

In recent years, the development of inter-city competitions and the growth of city-beautiful movements have resulted in bringing some pressure to bear on service company executives to clean up their yards. Chambers of commerce and other organizations interested in civic dressing-up have realized that the water levels—points of entrance and points of interest for visitors—are actually civic front yards. Considerable progress in the curing of these scenic sore spots has been made through coöperation of these organizations and utility companies.

In few places, however, have the full possibilities of this development been realized as they have in West Texas.

In West Texas, no one mentally links a power company with the unsavory settings of the average city waterfront. It has been the fortune of West Texas Utilities Co., serving 111 communities electrically in this section, to appreciate since its organization the value of



PARK SURROUNDING PLANT AND SUB-STATION AT BALLINGER, TEXAS

architectural leadership in a country which, at that time, was just laying its cornerstone.

The territory served by this company is primarily rural, but the company was appreciative of the fact that the extent and character of the natural resources with which the section is endowed would lead inevitably to an industrial and commercial development destined to transform lonely prairies into humming villages and villages into cities in a comparatively short time. Sensitive also to the fact that an adequate power supply was the forerunner of this development, the company determined to make its physical properties architectural models for the builders to come.

The company selected a type of architecture in harmony with the climatic conditions and historical associations of West Texas, thus creating a true symbol of the integration of the company and the country it serves.

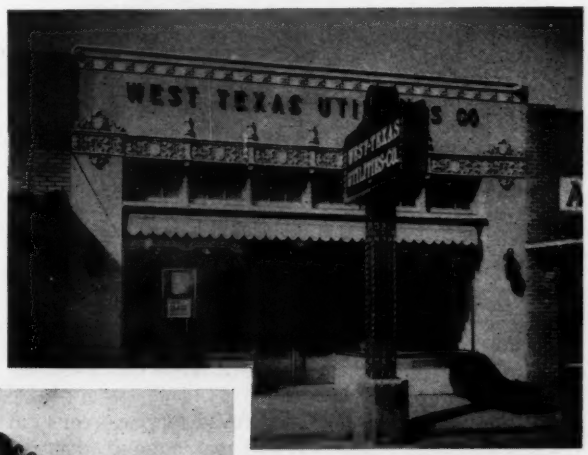
By selecting and adhering to the Spanish and Mission styles in its buildings and giving them a setting wherever possible in landscaping and flora appropriate to the region —live oaks, vines and other plants—the company has visualized itself in an agreeable manner.

Artistic embellishment and landscaping of its properties have been in the hands of experts, who thoroughly understood the company's aims and purposes.

The company capitalized upon the advantages of location and the nature of its fuel supply by erecting buildings designed to add positive aesthetic appeal to its natural surroundings. Tile, brick and buff stucco, offset with ornamental iron decorations have characterized these buildings. Fire resistant materials have been used throughout and a stricter observance of standard building codes kept than was sometimes made necessary by local laws.

Lighting installations in these buildings have been models of technically correct and artistically attractive commercial lighting with a resultant effect upon the company's commercial lighting load.

This scheme has been carried out in the construction



of the company's three major generating stations, most of its auxiliary stations and substations. Its offices and display rooms both new and remodelled, lend a high architectural tone to the streets on which they are located.

In West Texas, the power company has actually been given a setting in the "front yard."

Its properties are pointed out to visitors. New buildings being erected in the vicinity take their architectural inspiration from these properties. They have stimulated civic pride, and given strength to city-betterment movements.

Better homes and better living are encouraged in such an environment, and this, in turn, is reflected in gains of productivity and purchasing power.

Benefits which have accrued to the company through execution of this policy are intangible and not easily measured by ordinary engineering standards.

The effort has earned immeasurable dividends of good will. It has given the company a constructive part in the communal affairs of the section—a position of leadership which it is singularly fitted to fill.

Such relations must inevitably show substantial returns in the company's balance sheet, even though they may not be easily identified.

In the accompanying illustrations on this page are shown some of the office buildings in various towns served by the West Texas Utilities Co. The view at the top is typical of most of the offices. In the center is shown the front of the office at Albany, Texas, and at the bottom the office building and ice plant at Menard.

Frequency and Load Control on Electric Systems

INTER-CONNECTION OF SYSTEMS, NECESSITY FOR CONSTANT FREQUENCY AND ECONOMICAL LOADING OF UNITS DEMAND IMPROVED CONTROL OF UNITS. BY S. LOGAN KERR*

WITH THE GROWTH of power systems, with widespread inter-connection and the increased dependence of industry upon electric power, new and more involved operating problems have arisen and the whole aspect of power plant operation has changed. It is no longer sufficient merely to deliver continuous electric service, as it now must be supplied at constant voltage with constant frequency and in the most economical manner possible. At the same time, each power company must live in peace with its neighbors and must also coöperate with them in the form of inter-connections and power interchange.

Of these three factors of improved service,—constant voltage, constant frequency and maximum economy,—the first has received the most attention and, while improvements are being effected to stabilize voltage still further, the other two factors have not received as much attention. Moreover, the elements of the solution of the two remaining factors are more involved and are less generally known.

Constant frequency, the second factor in the new standards of electric service, is greatly involved and subject to many local conditions each of which must be studied carefully to arrive at the proper solution of the problem as a whole.

The factor of maximum economy is rapidly coming to the fore as an essential element in effecting constant frequency. It is possible to maintain constant frequency but at an expense that far outweighs its intrinsic value.

INDUSTRIES REQUIRE CONSTANT FREQUENCY

Attention has been drawn from time to time to the need for constant frequency. One of the first to emphasize this need was the textile industry and particularly the silk mills.

The advent of the electrically driven paper machines furnished another source of worry.

Interconnections between systems still further concentrated attention upon the need for some sort of speed control which was more accurate, more positive and more reliable than the present equipment could supply.

These problems and many others deal only with constant frequency but the advent of the synchronous motor driven electric clock added one more refinement—constant average frequency.

These two latter terms have been used freely and it would appear at first that they are synonymous. Within limits, this may be true, if the frequency remains absolutely constant for a given period of time. It is

*Research Engineer, I. P. Morris and De La Vergne, Inc., Philadelphia. From a paper presented as part of a symposium on the subject at a special meeting of the Empire State Electric Association and published by permission of the association. This symposium is being worked into a report of the N.E.L.A. Hydraulic Power Committee, to be published soon.

FIG. 1. AUTOMATIC OPERATOR AT THE LEFT AND STATION SWITCHBOARD INSTALLED AT NORWOOD PLANT

possible, however, to operate for constant frequency and yet accumulate an appreciable error in time or to operate for constant average frequency and still be far from maintaining constant frequency.

The primary element for operation should be constant frequency, limiting the departure from normal speed to as small values as the physical characteristics of the system will economically permit and reducing the duration of the departures from normal to a minimum.

Constant average frequency merely adds a refinement, that of requiring a fixed number of cycles to occur within a finite time.

Limits of Control Dependent Upon System Characteristics

Practical consideration enforces certain modifications of the ideal system, for sudden applications or rejections of load, differences in system characteristics, differences in load and generating equipment characteristics all tend to change the frequency from normal and limits of control must be established with these factors in mind.

Various elements of these practical considerations must be studied before the frequency can be controlled successfully. The first of these may be termed the "variation characteristic" of the system and may be defined as the amount and rate of load change occurring during normal operation, exclusive of emergency conditions. This would be expressed in terms of kilowatts per second or the total kilowatt change in a given time.

The second consideration may be termed the sensitivity characteristic of the system and may be defined as the degree of speed change which will cause the generating units to pick up or drop load, based upon normal sensitivity of the governing equipment on these units. This would be expressed as an increment of frequency above and below normal.

System Speed Characteristic Defined

The third consideration may be called the speed characteristic of the system and may be defined as the rate of change of demand in kilowatts with respect to a given change of speed on the system. This may be expressed as the variation in output, as some function of speed, either as the first power, the square, the cube or some intermediate value.

Every system represents some different combination of these three considerations. The relations between the three and their individual values are also subject to changes at various times of the day, various days in the week, and even seasonal changes in sections of the country where the general activities vary materially with the seasons.

The third or speed characteristic is perhaps the most involved and is the one least susceptible to direct analysis. One extreme of the speed characteristic will be with pumping units or similar equipment on which the demand will increase approximately as the cube of the speed, thus increasing the demand rapidly for even small changes of speed. This is a direct variation and tends to stabilize conditions since an increase of speed will be followed by an increase in demand which in turn will tend to reduce the speed.

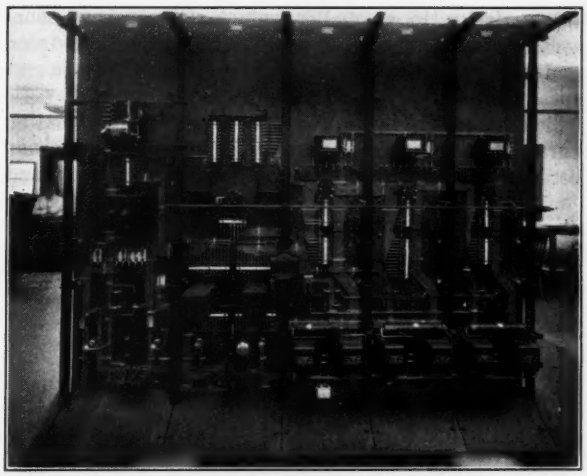


FIG. 2. REAR VIEW OF AUTOMATIC OPERATOR SHOWING WIRING AND RELAYS FOR ACTUATING GOVERNOR CONTROL MOTORS

The most usual type of load varies directly as the first power of the speed or is independent of the speed of the system. The lighting load and electric furnace load do not change in demand with changes in frequency of one or more cycles hence do not assist in the stabilization of the system and their speed characteristic will be equal to zero. In the case of electric furnaces, however, with a speed characteristic equal to zero, the variation characteristic may be very high with a correspondingly detrimental effect upon the system regulation.

All of these considerations are fundamental in nature and must be determined for each individual installation through a survey of the system or through tests conducted during operation.

Frequency Tolerance

With all of this information available, it is then possible to determine what may be defined as a "frequency tolerance," namely, the combination of two factors, the first of which may be defined as a sensitivity requirement fixed by the limits of the various customers, with consideration given to the type of load being supplied and the effect of speed changes upon the quality and production of the product. The second factor in determining the frequency tolerance is the rate at which power can be added or subtracted from the combination of generating units through the sensitivity of the governor, its permissible rate of movement and the limits of the generating equipment.

The element of electric timekeeping will also enter into this tolerance, but as a refinement which will correct the base about which the variations occur.

The question of economy also enters into the determination of this frequency tolerance since it may be desirable to limit the rate of change of power supply to a smaller value by permitting momentary departures in frequency of relatively small amounts.

With all of these fundamentals understood, and with due consideration to the magnitude of the connected load and generating equipment available, steps may be taken to improve the frequency conditions and reduce

the variation to a smaller value. Obviously a more sensitive type of control element must be introduced and a correction applied to compensate for the inherent speed drop, or no-load, full-load speed characteristic which is essential in the parallel operation of alternating current machinery to secure the proper load division between units and prevent unnecessary load interchange.

Correction for Inherent Speed Drop

A supplementary control which will tend to return the speed exactly to normal following a load change,

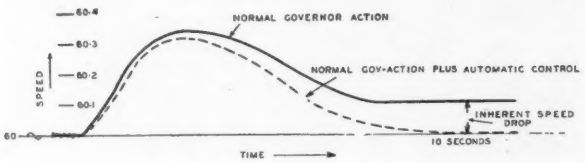


FIG. 3. TYPICAL RELATION SHOWING SPEED-TIME CURVE FOR LOAD REJECTION. GOVERNOR TAKES CARE OF REGULATION AND AUTOMATIC CONTROL COMPENSATES SIMULTANEOUSLY FOR INHERENT SPEED DROP, RETURNING SPEED EXACTLY TO NORMAL AT END OF LOAD CHANGE

will also correct for the inherent speed drop and at the same time, it will leave the governor free to take care of excessive speed changes occasioned by rapid changes in the load demand. If a more sensitive speed control element is introduced as a supplement to the governor, if properly timed, it will return the speed exactly to normal after the load change is over and it may also assist in reducing both the magnitude and the time of departure of speed from normal. The effect of this device must be carefully coördinated with the physical requirements of the hydroelectric plant, in order to avoid hunting or instability. In the case of a steam plant, the rate of movement may be increased materially over that permissible in a hydroelectric plant, since the inertia effect of the water column in a hydroelectric plant is not present in a steam station.

This applies to the control of a single unit. If, however, the control equipment is applied to more than one unit, there are many other considerations which enter into the problem, the first and foremost of which, however, is the question of economic load distribution between units, so that the combination of load is at all times in accordance with the requirements for the maximum combined economy.

This particular feature of the problem was mentioned as the third factor in improved service at the beginning of this discussion. Too much emphasis cannot be laid upon the desirability of maintaining rigid schedules for unit loading in order to reduce to an absolute minimum the operating losses on the prime movers. This is particularly true in hydroelectric plants where the storage of water is possible either for seasonal demands or for daily peak load service. This is also a factor of run-of-river plants where it is desired to obtain the maximum number of kilowatt-hours from whatever flow is present in the river. It is also of immediate interest in steam plants as the savings will be reflected at once in the amount of fuel used, and the consequent reduction in the operating cost.

It is essential in all of these studies on the application of automatic control equipment to generating systems that the three points of the following summary be given the utmost consideration:

(1) The operating problems of the individual system must be solved on that individual system before interconnecting with other systems having their individual problems. If this is not done, these individual problems become problems of the combination and do not necessarily iron themselves out on account of the larger system with which they are concerned, but rather tend to aggravate the troubles experienced due to the wider field through which their effects must be felt.

(2) A form of frequency tolerance must be established based upon the factors of system capacity, system load demand and load characteristics of the system and of the individual plant, and more important than all the foregoing, the inherent speed regulating characteristics of the system itself.

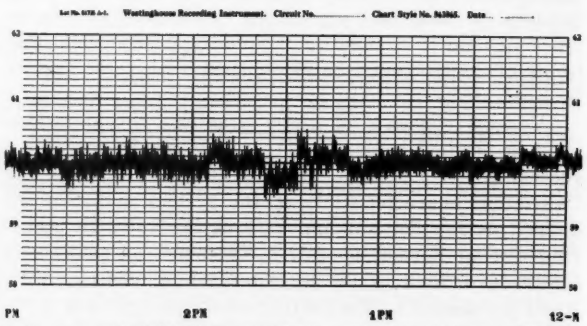


FIG. 4. FREQUENCY RECORD ON ISOLATED SYSTEM SHOWING MOMENTARY SPEED VARIATIONS DUE TO SEVERE TYPE OF LOAD FLUCTUATIONS. DEPARTURE OF BASE FROM NORMAL OF 60 CYCLES CAUSED BY LACK OF ADJUSTMENT OF SPEED OPERATORS

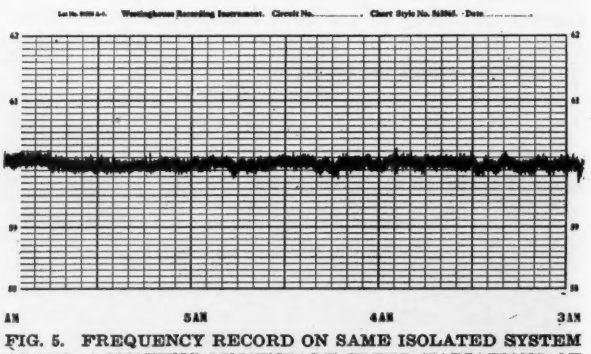


FIG. 5. FREQUENCY RECORD ON SAME ISOLATED SYSTEM AS FIG. 4 SHOWING MOMENTARY SPEED VARIATIONS OF REDUCED AMPLITUDE AND CLOSER ADHERENCE TO NORMAL 60 CYCLE FREQUENCY

(3) The design of the control equipment must be based upon the study of the economy features of the installation and the maintenance of proper operating schedules in order to secure the maximum economic utilization of the generating equipment.

The design and manufacture of water turbine equipment has long been recognized by the company of which the writer is a member as not the sole requirement, since uneconomical operation of the equipment will offset high efficiency characteristics with resulting lower yearly earning power. The operation of the plant can be scheduled to produce the greatest kilowatt-hour output from the available water and, if this schedule is related

to the efficiency characteristics of the turbine and is faithfully followed by the operators, the station losses can be reduced to a minimum.

Recognizing the difficulty of maintaining such schedules by manual control, this company has developed a complete system of speed regulation and economic unit loading which is intimately related to the efficiency characteristics and which is entirely automatic in its operation. It has also developed apparatus to control the most economical number of units in service for any given output, the automatic control for system reserve capacity and whatever other applications may develop in each individual case.

Actual field results from the use of this control have been most gratifying. Installations are now in operation or in the course of construction in five different power stations. These include the complete control for the Norwood Development, Carolina Power & Light Co., for a three unit station having a capacity of 87,800 hp., the Waterville Development, Carolina Power & Light Co., a three unit station, having a capacity of 135,000 hp., the Long Lake Development, Washington Water Power Co. with four units, having a capacity of 90,000 hp.; Post Falls Station, Washington Water Power Co. with five units, having a capacity of about 19,000 hp. and the Morony Development of the Montana Power Co. with two units having a total capacity of 62,000 hp.; making an aggregate capacity of 393,800 hp.

Reports which have recently been received from the Norwood Station indicate that the control equipment has been in commercial operation continuously for a period of 18 months and that during this time the total outage was less than 10 hr. and was due to causes other than the control equipment. There were no major repairs required and all maintenance was cared for by the local personnel. In addition, the operating efficiency of this station has been maintained at an exceptionally high level. Through the use of the control equipment, the operating losses have been reduced from 8 to 10 per cent to the order of 2.5 or 3 per cent when first installed and more recently to less than one-half of one per cent for appreciable periods.

An analysis showed these losses to be due only to having extra units in service when carrying system reserve capacity, or failing to have the proper units available for operation at the required time. All losses due to improper loading of units have been completely eliminated.

Unloading Frozen Coal Cars

By Edw. Luxemberg*

DURING the record cold weather that gripped St. Louis in January and sent the official thermometer to 13 deg. below zero, much trouble was encountered at Cahokia in unloading frozen coal. The inside bunkers hold enough coal for only a day's use and must be replenished each twenty-four hours, seven days a week.

The first week of the new year was accompanied by a continual rain which was followed by snow and a rapid drop in temperature. During this period, cars of coal had been in transit from 3 to 10 days between mine and plant. During that time, they became thoroughly soaked and froze so hard as to stick in the cars solidly, even when they were completely turned upside down in the car dump.

All sorts of methods were resorted to in an effort to thaw out the coal. After bringing a wooden car to the dumper, one method was to bore small holes in the sides

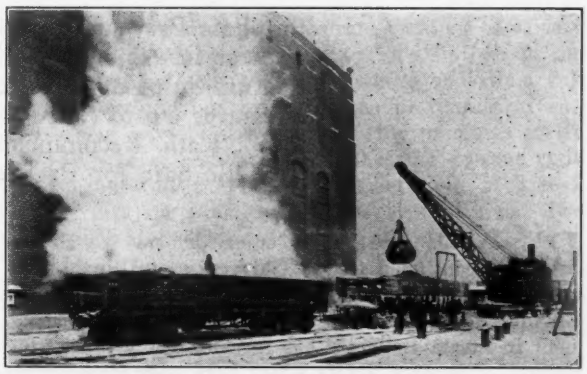


FIG. 1. THAWING OUT A CAR OF COAL WITH STEAM JETS

near the bottom and insert steam jets. This was very successful but not many of the 45 cars received a day are wooden. With steel-sided cars, it was necessary to heat them from the outside with wide-flame, low-temperature blow torches, while an extra force of men worked inside the cars digging the coal loose with picks. This would sometimes take a half hour for one car. It

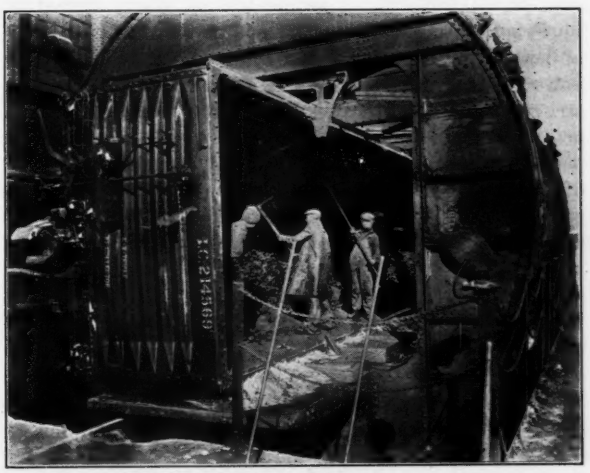


FIG. 2. A STEEL CAR FROM WHICH THE FROZEN COAL HAD TO BE REMOVED WITH PICKS

can readily be realized that both of these methods are slow and tedious but no other more rapid way is possible and in unloading coal for Cahokia, speed without interruption is essential.

The latest advices indicate that the construction program of electric power and gas utilities contemplated last December will probably be exceeded in 1930. The output of electric power for the first quarter exceeds 1929 by about 3 per cent. Sale of manufactured gas in April exceeds last April by about 2 per cent.

*Mechanical Supt. Cahokia Station, Union Elec. Light & Power Co., St. Louis. From the Union Electric Magazine.

Recent Developments in EMBRITTLEMENT RESEARCH

By Frederick G. Straub

Sulphate Prevents Embrittlement Only When It Is Present in Amounts which Will Cause the Solid Sodium Sulphate to Form in the Seams. Studies at Pressures Up to 1300 Lb. Indicate that the Present 3 to 1 Ratio Recommended by the A.S.M.E. Code Will Be Safe for Practically All Boiler Pressures.

RESEARCH WORK on embrittlement, which has been continued at the University of Illinois since the publication, in June, 1928, of Bulletin 177 of the Engineering Experiment Station entitled "Embrittlement in Steam Boilers," has revealed many interesting results. The main points which have been investigated are:

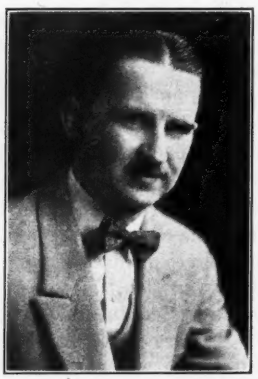
1. Possibility of new steels to resist caustic attack.
2. Mechanism of concentration of boiler water in seams.
3. New inhibiting agents to prevent embrittlement.
4. Behavior of new inhibiting agents in boiler waters under boiler conditions.
5. Determining the proper sulphate ratios to prevent embrittlement.

Previous publications have shown that embrittlement of boiler plate is due to the combined action of stress and chemical attack. The stress is inherent in the construction and operation of the boiler, while the chemical attack is caused by the sodium hydroxide in the boiler water concentrating in the capillary spaces in the seams of the boiler. It has also been shown that embrittlement cracking may be readily distinguished from corrosion, pitting, fatigue and corrosion fatigue. Furthermore, the causes of embrittlement are entirely different from those causing corrosion, pitting, fatigue and corrosion fatigue. One would not expect to prevent these difficulties in the same manner as embrittlement is prevented.

Corrosion, as the name implies, is due to the direct corrosion of the metal. This follows in principle the well-known phenomenon where parts of a metal differ in composition or physical properties from other parts, due to strains, density, or impurities; in the presence of an electrolyte a corrosion area is developed. These corrosion areas or cracks, in the case of a metal under stress, will follow the lines of stress, as would naturally be expected. Also, since the solvent action is accentuated or occurs in the presence of that type of ionization wherein the hydrogen ions predominate, one would expect to find such examples of corrosion in the presence of electrolytes such as nitrates, chlorides, or sulphates. Such corrosion phenomena would be inhibited by the presence of hydroxyl ions or that condition where an alkaline state exists. This in itself explains why one would not expect to find corrosion cracks in boilers using waters which are alkaline in character.

Some confusion may have been caused by recent publications which stated that cracked boilers had been found where the waters were free from sodium hydroxide and the sulphate to hydrate alkalinity ratio was naturally infinitely large. Unfortunately the writers of these articles failed to call attention to the fact that these cracks were not seam cracks, but were corrosion and corrosion fatigue cracks occurring in the main plates in contact with the water. Naturally, a water low in hydroxide and high in sulphate, as stated above, would tend to accentuate the corrosion cracking and sulphate to alkalinity ratios could not be considered as a means of preventing this action.

This discussion of embrittlement cracking is limited to the rivet hole cracking which occurs in the seams of steam boilers, and no attempt has ever been made to include all boiler cracks under this heading.



FREDERICK G. STRAUB has been conducting the special research for the Utilities Research Commission on boiler feedwater treatment for the last five years at the University of Illinois. This work has dealt primarily with determining the cause and methods to be used to prevent embrittlement in steam boilers. Mr. Straub was graduated from the University of Illinois in 1920. In that year, he became a research fellow at Mellon Institute and later entered the employ of the Semet-Solvay Co., Syracuse, New York. In 1921, he became associated with Pennsylvania State College, where he received his M.S. degree in metallurgical engineering in 1923 and then was connected with the Guggenheim Brothers Research Laboratory, until he resigned there to return to the University of Illinois.

Data from research being conducted at the University of Illinois in coöperation with the Utilities Research Commission of Chicago, and authorized by Dean M. S. Ketchum of the Engineering Experiment Station. Complete results of the embrittlement research work will be available shortly as a bulletin of the Engineering Experiment Station of the University and those interested should communicate directly with the author, who will arrange to have copies forwarded to them as soon as the bulletin is published.

New Alloy Steel Not Embrittled by Caustic Solutions

If this type of cracking is the result of the action of solutions of caustic soda on stressed steel, one would naturally seek steels which would resist this chemical attack even when highly stressed. A large number of special steels alloyed with manganese, silicon, zirconium, aluminum, vanadium, molybdenum, nickel, and chromium have been tested, and only one steel has been found which will withstand the action of caustic solutions. This steel is a high chromium steel which is not readily adapted to fabrication of steam boilers. Consequently, it is felt that other methods of attack must be attempted to prevent the cracking.

Concentration in Seams

Since a dilute solution of sodium hydroxide such as exists in the main body of the boiler will not cause embrittlement, concentration of the solution in the capillary spaces in the seams is essential before cracking may take place. A study of the mechanism of this concentration effect has shown that the finer the capillary, the faster concentration takes place and, furthermore, concentration takes place in the absence of leaks to the outside. This indicates that where there is a possibility of boiler water seeping into the seams, concentration will readily take place; however, if the seams are properly inside calked, the water will not be able to penetrate into the spaces in the seam, concentration will not take place and embrittlement will be prevented.

New Inhibiting Agents to Prevent Embrittlement

In boilers so constructed that there is a possibility of boiler water entering the seams, the only method of preventing embrittlement is to maintain in the boiler water certain chemicals which will prevent the caustic solution from attacking the highly stressed metal adjacent to the rivets. New inhibiting agents have been developed in the laboratory. These are chromates, nitrates, tannates, acetate and phosphate. Each of these agents has been tested and the amounts necessary to prevent cracking have been determined. Before these agents may be recommended for boiler operation, they should be studied in actual operation and such tests have been made.

Behavior of New Inhibiting Agents in Boilers

Tests made in a steam boiler using the various inhibiting agents revealed interesting results. The chromate was very unstable and would readily decompose; consequently it is of no use in boiler operation as far as the prevention of embrittlement is concerned. Tests run on boilers having 1000 p.p.m. of chromate showed no chromate after 48 hr. operation. Nitrate is very stable even at 500 lb. steam pressure in the presence of sodium hydroxide. Tannate and acetate are very unstable. A solution of 100 p.p.m. of tannate in the presence of sodium hydroxide under 500 lb. pressure decomposed within 24 hr. operation. Phosphate is exceedingly stable and in alkaline solutions in the absence of calcium will remain in the boiler water. Several large power plants are using phosphate to prevent embrittlement. These plants are being closely watched. Phosphate should be used only when the operators are certain they have a definite amount present in the boiler water at all times.

Proper Sulphate Ratios to Prevent Embrittlement

The research work has shown that sulphate prevents embrittlement only when it is present in amounts which will cause the solid sodium sulphate to form on the metal in the capillary spaces in the seams Thus, if sufficient sulphate is present so that the solution becomes saturated in respect to sulphate before the hydroxide becomes sufficiently concentrated to cause embrittlement, no cracking will take place. Studies have been made of the solubility of sulphate in hydrate solutions of various concentrations at pressures up to 1300 lb. From the results of these tests, the proper ratios of sodium sulphate to sodium hydroxide for the prevention of embrittlement have been worked out for pressures up to 1300 lb. These results indicate that the present ratio recommended by the A.S.M.E. Boiler Code of 3 to 1 will be safe for practically all boiler pressures. The lower ratio of 1 to 1 is a trifle low and should be raised to at least 2 to 1.

Why Boilers Not Having Sulphate Ratios Do Not Crack

The author has been much interested in studying power plants using high alkaline waters low in sulphate which have operated for years without any indications of embrittlement. A careful analysis of the conditions of operation shows that these plants have a large percentage of the alkalinity of the boiler water present as sodium carbonate and only a small percentage as sodium hydroxide. At no time has it ever been stated that sodium carbonate causes embrittlement and the author stated in his first publication in 1926 that sodium carbonate could be considered as an inhibitor of embrittlement. Little attention has been paid to this property of sodium carbonate, since it has not been realized that a large percentage of the alkalinity might remain in some boilers as sodium carbonate. A survey of many plants shows that frequently plants operate with the sodium carbonate much higher than the hydroxide in the boiler water. This condition appears to be characteristic of certain types of feedwaters and a laboratory study is being made in order to determine why these plants have this characteristic type of boiler water.

A study has been made in regard to the influence of sodium carbonate in preventing the embrittlement. Ratios which involve both the sodium carbonate and the sodium sulphate as the numerator, and the hydrate as the denominator, have been worked out. These show that when a high rate of hydrolization takes place in the boiler water a higher sulphate to hydrate ratio is necessary, and when the hydrolization is low, a lower ratio would suffice. Thus, with 80 per cent of the alkalinity as sodium hydroxide, a ratio of $\frac{\text{Sodium sulphate}}{\text{Alkalinity}}$ of 3 should be protective for all pressures; when the sodium hydroxide is but 50 per cent of the alkalinity, a ratio of 2 would be protective; if the sodium hydroxide is but 20 per cent of the alkalinity, a ratio of 0 would be protective.

This shows that certain boilers having high alkalinities with low sulphate could be free from embrittlement, while others of lower alkalinities and higher sulphate would encounter embrittlement.

Planning POWER SUPPLY SYSTEMS *For Large Cities*

By A. H. Kehoe
Electrical Engineer, United Electric Light & Power Co.

POWER COSTS are constantly being lowered by the activities of station designers and operators, and with every progressive step there spring up additional plants due in no small measure to the improvements in efficiency which are being made. Such developments require system readjustments, in order both to utilize the efficient power from new equipment and to maintain proper system reliability. Interconnection of systems has also accelerated these conditions in areas where readjustments might otherwise have been delayed a number of years. At present, in most large cities the plant engineers are no longer considering design and operation on the basis of separate power plants. They deal with such matters as integral parts of a single system.

Arthur Henry Kehoe, Electrical Engineer of the United Electric Light and Power Co., of New York, was born in Bennington, Vermont, February 18, 1889. He attended preparatory and high school in Bennington, Vt., graduating from latter in 1907. In 1911 he was graduated from the University of Vermont, at Burlington, Vt., with degree of B.S. in E.E.

Entering the employ of the United Electric Light and Power Co. in October, 1911, as Engineering Assistant, he was made Superintendent of Transmission and Distribution in September, 1919, and Electrical Engineer in October, 1921. In the latter capacity, he had general supervision of electrical engineering, operations, and maintenance—embracing transmission and distribution (including substations), transportation, meters and shops.

He is a member of Phi Delta Theta, Phi Beta Kappa, Engineers Club, Fraternity Club (N. Y.), Yountakah Country Club (Nutley, N. J.), etc.

Fellow in A.I.E.E.; Member of N.E.L.A.; Member N.F.P.A. Elec. Comm.

System Planning

System planning is a term employed by many engineers to incorporate all of the main features of design and operation for the entire system. Certain conditions, such as location and type of both population and industries, or available power sites, are fundamentals which cannot be modified in any important way by the system planning engineer. Between the various generating sites, however, and the points of utilization lies the power supply system with many possible variations. This is the field of system planning.

It can be assumed that for any definite territory there should be a preferred system plan. To date, local conditions in the large cities have been ruling in their influence, and mask any classification of the ideal plan for their varying requirements. While there are at present several different fundamental plans in operation for each one of these, new principles and practices are being set up from year to year which materially affect the design and operating requirements of many parts of a system, including the power plants themselves. On large systems, today there are important interrelations between all elements in the supply system which must be taken into consideration by the power plant engineer.

Reliability at Minimum Costs

Reliability of service with minimum supply system costs is vital to everyone connected with a project. The normal life and business of our large cities have become dependent upon reliable electric service, hence complete and continuous service is the general aim. It is natural that the huge concentrations of power by metropolitan central station companies make an acute problem of obtaining reliability without increasing system costs. Experience has shown that failures must be expected anywhere on the system. For reliability, in addition to eliminating the fault, there must be sufficient reserve capacity available to avoid an interruption to consumers' service as well as to prevent a plant overload. While considerable variations still exist because of local situations, there is carried, usually, a definite operating reserve which is not less than the largest generating or feeder unit in operation.

Early developments of distribution and utilization caused no noticeable reactions in the generating stations, which were designed primarily as self-contained units. System conditions external to the station, however, had to be considered as soon as other stations were connected to the system. This was due either to the increase in loads or to interconnection, which caused power concentrations many times the magnitude of those experienced when the first station was designed. The principal modifications in power plants were developments in station bus plans.

Various types of bus and reactor layouts have been devised and installations today are classified as "ring bus" or "star bus" types. In the ring bus, reactors are used to connect adjacent sections. Finally, the first section and the last section are similarly connected through a reactor and the "ring" is formed. In the star or synchronizing bus plan, each bus section is connected through a reactor to one common or synchronizing bus.

There have been similar variations in the installation of reactors, which are used, in most cases, in one or more of the following locations: in the generator leads to the bus; in the outgoing feeders; between bus sections in ring bus plans; or, between generator leads and synchronizing bus in the star plan. Combinations of reactors in several of the foregoing locations have been numerous. Their installation reduced the size of switches which otherwise would have been required for the concentrations selected, minimized voltage disturbances on faults and improved stability of operation. While the different types of bus and reactor plans are well defined, the different power systems throughout the country have wide variations in their present design practices concerning them.

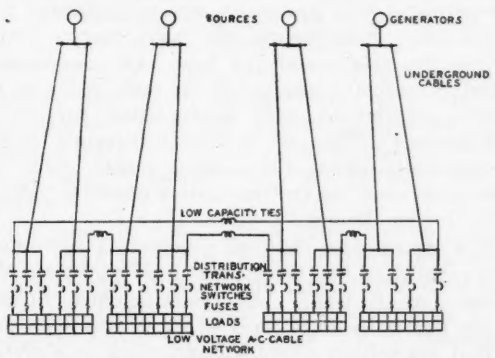


FIG. 1. SCHEMATIC CONNECTIONS OF THE LOOSE LINKED SYSTEM

System Connection Plans

There has also been a great diversity in the plan of system connections where a number of generating stations have been used to supply large cities. It has been found with the multiplication of generating source and of transmission and distribution facilities, that faults and operating mistakes are likely to cause extensive disturbances, particularly when two or more happen in sequence.

Electrical faults from a variety of causes require protective relay systems which relate the power plant equipment to the rest of the supply system very closely. In case the protective equipment fails to eliminate an electrical fault properly, there is always the danger of the resulting disturbance causing the loss of more capacity than the operating reserve, with the result that service interruption occurs. Furthermore, with extension of the system, a concentration of capacity occurs which makes it expensive to maintain safe switch rupturing capacities, and in any case, voltage disturbances during faults will expand normally in magnitude and number as the supply system loads increase.

Every large city recognizing these conditions has used designs which minimize such effects for its local condition and at the same time has met its reliability requirements. Certain cities have subdivided their areas, apportioning district loads to each generating station. This has been designated as the "loose linked" or "loosely connected" system plan. Figure 1 shows such a system with network distribution assumed direct from the generating stations. Other cities have provided high capacity tie lines between stations and have intermeshed feeders from two or more stations into each district, this being the "close linked" plan, as shown in Fig. 2. Recently, in addition to the normal and back-up relay protection for faults, certain otherwise close-linked systems have provided for provisional splitting into parts of approximately equal capacity in case of major system faults. Such an arrangement ordinarily does not divide the areas supplied into districts, but does limit the capacity in any district which may be affected by a serious system fault.

The plan of system connections to be used in the case of large cities has been the subject of two symposiums recently before the American Institute of Electrical Engineers. At the 1930 Mid-Winter Convention in New York, the systems in use in Chicago, Detroit and Philadelphia were described. At the 1929 Summer Convention in Swampscott, Mass., the "Synchronized at The Load" arrangement in use on the 60-cycle system in New York was discussed.[1] All of this material is a part of the printed record of the Institute in their transactions.

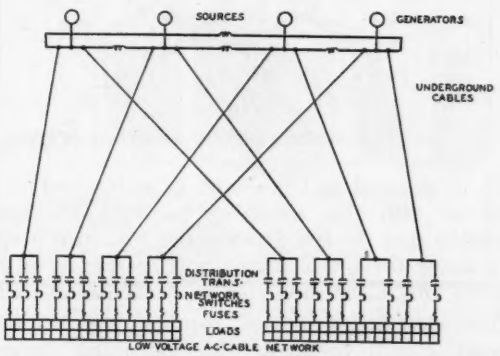


FIG. 2. DIAGRAM OF A CLOSE LINKED SYSTEM

Close-Linked vs. Loose-Linked Systems

The metropolitan areas of Philadelphia, Chicago and Detroit utilize some form of the close or loose-linked systems. These localities, like most large city systems, have within their boundaries large generating plants, but in many cases, through high voltage interconnection, they receive and send some power over considerable distances.

Philadelphia's close-linked system is considered as a unit, with provisions for reserve capacity at all points and for relaying to permit the prompt elimination of

[1] A.I.E.E.—"System Connections and Inter-Connections—Chicago District," by George M. Armbrust and Titus G. LeClair. "The Fundamental Plan of Power Supply of The Detroit Edison Co.," by S. M. Dean. "Fundamental Plan of Power Supply in The Philadelphia Area," by Raymond Bailey. "Synchronized at the Load"—(1) A Fundamental Plan of Power Supply, by A. H. Kehoe; (2) Calculations of Systems Performance, by S. B. Griscom; (3) System Tests and Operating Connections, by H. R. Searing and G. R. Milne.

any line or piece of equipment on the occurrence of a fault. The distributing centers normally are tied together with high capacity lines permitting the use of power from the more efficient steam plants, hydro stations and interconnection.

In Chicago, the system embodies the close-linked scheme and is arranged so that it will divide into two sections when an emergency exists. There is no interconnection at generator voltage, but there is rigid connection between generating stations at higher voltage.

In Detroit, with the loose-linked arrangement, each district is considered as a complete unit being served by its own power house or step-down substation, being normally tied to allow for transfer of load up to about the capacity of one machine.

With the close-linked system, it is essential that synchronism be maintained not only between all units in one station but also between all stations. With the district arrangement, the loose-linked system, the load is definitely allocated to one adjacent station, wherein

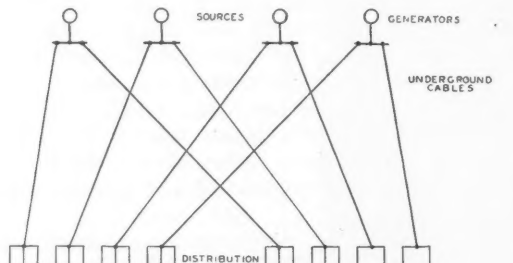


FIG. 3. THE SYNCHRONIZED AT LOAD SYSTEM

it is not essential that it should be maintained in synchronism with the remaining parts of the system. Assuming that the low capacity ties will open properly on a major fault, this station will operate as an independent unit, alone supplying its particular district.

The close-linked system requires high rupturing capacity circuit breakers, with increasing rupturing duty as the capacity of the system is increased. The fault protection is complicated and positive back-up protection is difficult to obtain in case the primary protection fails. During system faults, service voltages are subject to excessive drops caused by concentrations of current at the fault. Finally, the entire system service is at stake in case of a series of major faults.

Loose-linked systems, on the other hand, by subdivision of the load, eliminate the likelihood of an entire system shutdown, but do increase the probability of interruptions to each district. In addition, each station must have some efficient units if economical results are to be obtained. These systems, except at their district border fringes, cannot obtain the economies and reliability from diversity of a multiplicity of sources of supply. In other words, the loose-linked scheme postulates that a power system can become so large that it is either economical or imperative to divide it into a number of separate district power systems in order to obtain reliability.

In addition to the close-linked and loose-linked schemes, there is the "synchronized at the load" plan (shown in Fig. 3 for network distribution), which embodies many desirable characteristics for a system plan.

In New York City, the 60-cycle system is operated, synchronized at the load. In this arrangement, the generating units operate in parallel, connected together only through the load. Each generator while in service on this system is described as being "synchronized at the load." This term refers to the conditions under which each unit is maintained in synchronism, but it does not refer necessarily to the initial synchronizing of one generator with the rest of the system. Such a scheme of connections gives high reactance values for the synchronizing power circuits between the several generating units in comparison to the values which are in general use with generators also synchronized at the station bus. Nevertheless, the main energy channels between generators and the load have reactances, in respect to normal capacity, of the same order as those usually experienced with metropolitan underground cable systems. Thus, while this arrangement does not fundamentally affect the normal power distributing characteristics of the system, it does improve system behavior during abnormal conditions.

This system uses the load points as a short-circuit-proof-paralleling bus for all the units which are "synchronized at the load." As was anticipated, in applying the principles established by experience with multiple feed low-voltage network distribution to a group of generators multipled only on a low-voltage network, as long as the system is stable, the following desirable conditions result: (a) highly reliable sources of supply, since they are not affected simultaneously by faults; (b) positive back-up fault protection; (c) minimum fault current concentrations; and (d) minimum service voltage disturbances.

Synchronizing power for the New York system with this arrangement has been found to be adequate. While it is less under normal conditions than that which is obtained between individual units synchronized at the sources, yet the effective synchronizing ability at the time of a disturbance is approximately the same as with a close-linked system, due to the reduced magnitude of possible faults.

The assurance of reliability of system supply for any one fault is secured by the following considerations: Sufficient generating sources are "synchronized at the load" on a system having ample synchronizing power between the units to produce stable operation between all sources for any single fault regardless of its location, provided the fault is eliminated promptly by protective equipment. As long as enough such independent sources are in service to maintain the load, the loss of the reserve part of the capacity will not result in an interruption, since the remaining capacity is not jeopardized by this loss. The ability of a low-voltage distribution network to eliminate its own faults, where this is required, provides positive back-up protection even though a reasonable percentage of subsequent failures of protective equipment do not eliminate the original fault. Where the system has radial service supplied from a substation, the low-voltage bus, such as the 4-kv. substation bus, is the last common load point, and must be used for synchronizing at the load. In this case, protective devices are relied upon for secondary protection,

as there are usually a number of protective devices in series backing up each other for a major fault. In the extreme condition, where a fault is not eliminated because the protective equipment fails, an interruption will result only to the substation where such failure occurs.

With the system synchronized at the load, the current and load division between feeders may be affected somewhat except for peak conditions, when results should be the same. The magnitude of this effect, however, does not make it a major consideration. Similarly, the load from each generator (or bus section) is scattered to as many different load centers as possible in order to give the system the reliability obtainable by diversity of supplies from a number of independent sources. If this is carried to extremes, however, the mean length of feeder will be increased unnecessarily. It is pointed out that all units do not have to feed each and every load point, and we do not experience any increase in feeder lengths. It is also noteworthy that additional capacity is being supplied at lower installation costs because of smaller capacity required for electrical connections.

The arrangement makes the maximum short-circuit currents much less than are experienced on a system having a number of generators concentrated on a single bus. Furthermore, additions to system capacity do not increase the switch rupturing duty beyond the amount required by the first installation as long as the same generating capacity is maintained on existing sections.

Since the magnitude of fault currents is materially reduced and since currents from all other units must feed through the load into the fault, the resultant voltage disturbances due to system faults are materially reduced. System service voltages during major faults approximate 60 per cent to 90 per cent of normal instead of 20 per cent to 50 per cent of normal.

With ample synchronizing ability inherent in the system to given stability to a number of independent power sources, whether located in one or several different generating stations, generators synchronized at the load can be connected by supply feeders to a number of load points, thus making it impossible for one fault to affect all of the generating capacity; hence, if sufficient reserve capacity is in operation, the loss caused by a single fault cannot affect the reliability. By this method, reliability of supply depends upon having immediately available sufficient spare capacity in operation to compensate for a maximum number of possible major faults which are reasonably likely to occur in the interval required to get spare capacity in operation.

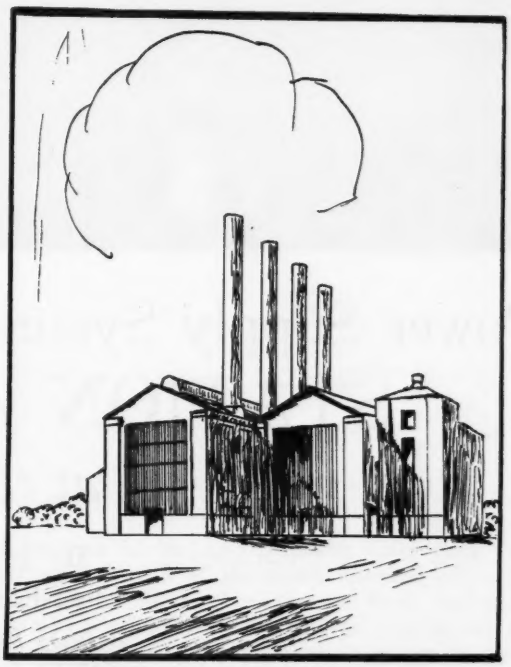
Power Supply Systems in Flux

Power supply system arrangements for large cities are now in a state of flux. They offer opportunities for great flexibility in planning and thus for great diversity in arrangement.

Such system connection schemes as synchronized at the load, the use of double winding generators or transformers, isolated phase construction, current-limiting reactors, high speed circuit breakers, improved excitation systems, or synchronous condenser applications are elements of design which should be considered in planning systems to meet service reliability requirements with minimum system costs. The preferred type of system connection should also allow indefinite expansion without incurring abnormal obsolescence charges. It should be a simple type to accommodate rapid and extensive growths as permanent parts of normal system expansion.

New Plant Serves Oil Refinery

ONE OF THE interesting power plant projects now in service is the new 640-lb. gage, 750-deg. F. plant of the Louisiana Steam Products Co. at Baton Rouge, La. This plant will supply steam and electric power to the refinery of the Standard Oil Co. Surplus

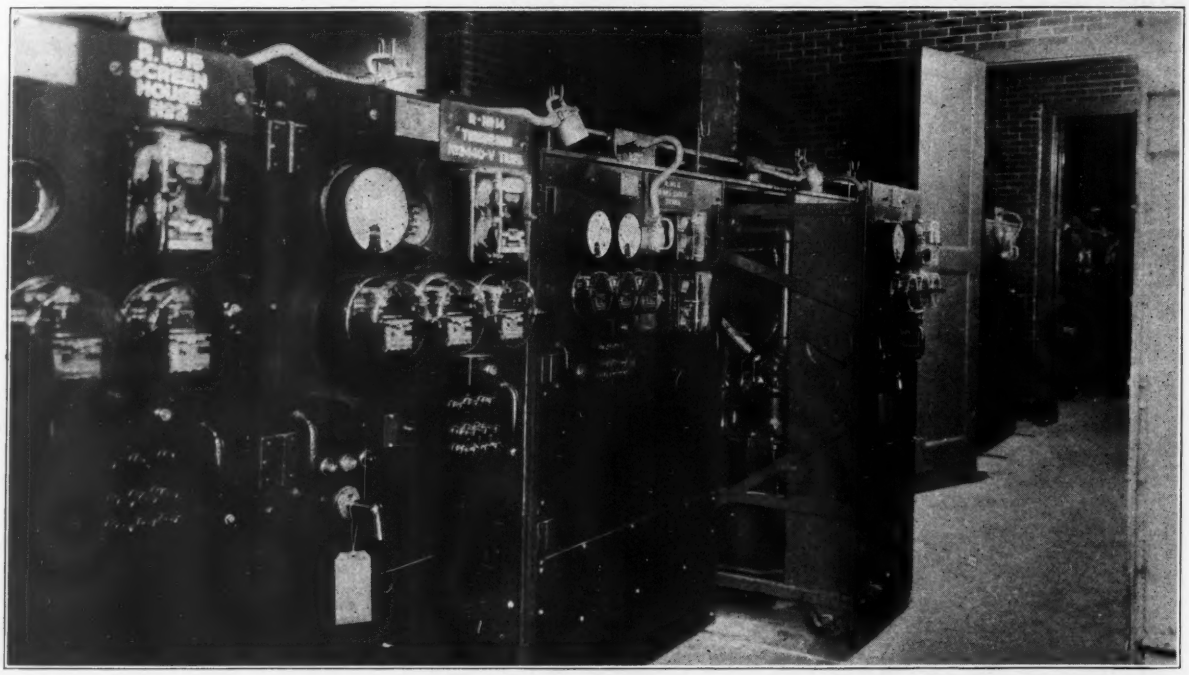


ARCHITECTS VIEW OF THE LOUISIANA STEAM PRODUCTS CO. PLANT AT BATON ROUGE, LA.

electric power will be absorbed in the system of the Engineers Public Service Co., which, like the Louisiana Steam Products Co., is a Stone & Webster subsidiary.

The new station will have an initial capacity of 45,000 kw. in three units, the turbines taking steam at 625 lb. and exhausting at 140 lb. for process work and driving plant auxiliaries. Natural gas will form about 50 per cent of the fuel, the remainder being made up of refinery residue, mostly sludges and petroleum coke with fuel oil available for standby. Feedwater makeup will run about 80 per cent so that the design will incorporate an unusually complete water purifying system. The plant costing approximately $6,000,000 was completed in about 7 mo.

Air Preheater Corporation states that the figures of 8,000,000 boiler horsepower in service shown in May 15 advertisement was in error because of the decimal point. The figure should have been 800,000 instead of 8,000,000. The company, not wishing to appear to exaggerate, requests this correction.



Power Supply System *for* STATION AUXILIARIES *at the* James H. Reed Station

By H. W. Eales
Chief Electrical Engineer
Byllesby Engineering & Management Corporation, Chicago

IN THE APRIL 1, 1930 issue of this paper, on pages 366-373, there was presented a general description of the new James H. Reed steam power station of the Duquesne Light Company, which is now nearing completion on Brunot Island at Pittsburgh.

For convenience, it may be repeated that the present power-house building has been constructed of sufficient size to house two 60,000-kw. steam turbine units, but that initially only one 60,000-kw. turbine unit is being installed, together with three 400 lb. gage boilers, each capable of producing 275,000 lb. of steam per hr. normally, and a peak output of 350,000 lb. of steam per hr. The purpose of this article is to give a more detailed description of the power supply system adopted for the station auxiliaries than was possible in the space of the general article referred to.

The fundamental requirements set up for the purpose of determining the type of connections and arrangement of electrical equipment for this station were: (a) simplicity, (b) reliability, and (c) lowest cost consistent with the two foregoing requirements. In the study of these requirements it was believed that, while a conventional arrangement of providing electrical switching connections in duplicate might furnish maximum overall reliability from the standpoint of availability of reserve equipment, this arrangement does not necessarily provide maximum instantaneous reliability from the standpoint of operation on account of the complications involved in the duplication of circuits, switches, controls, etc. It was further believed that simplification of connections and reduction in quantity of electrical equipment might be obtained, provided the station auxiliary equipment might be combined into suitable units

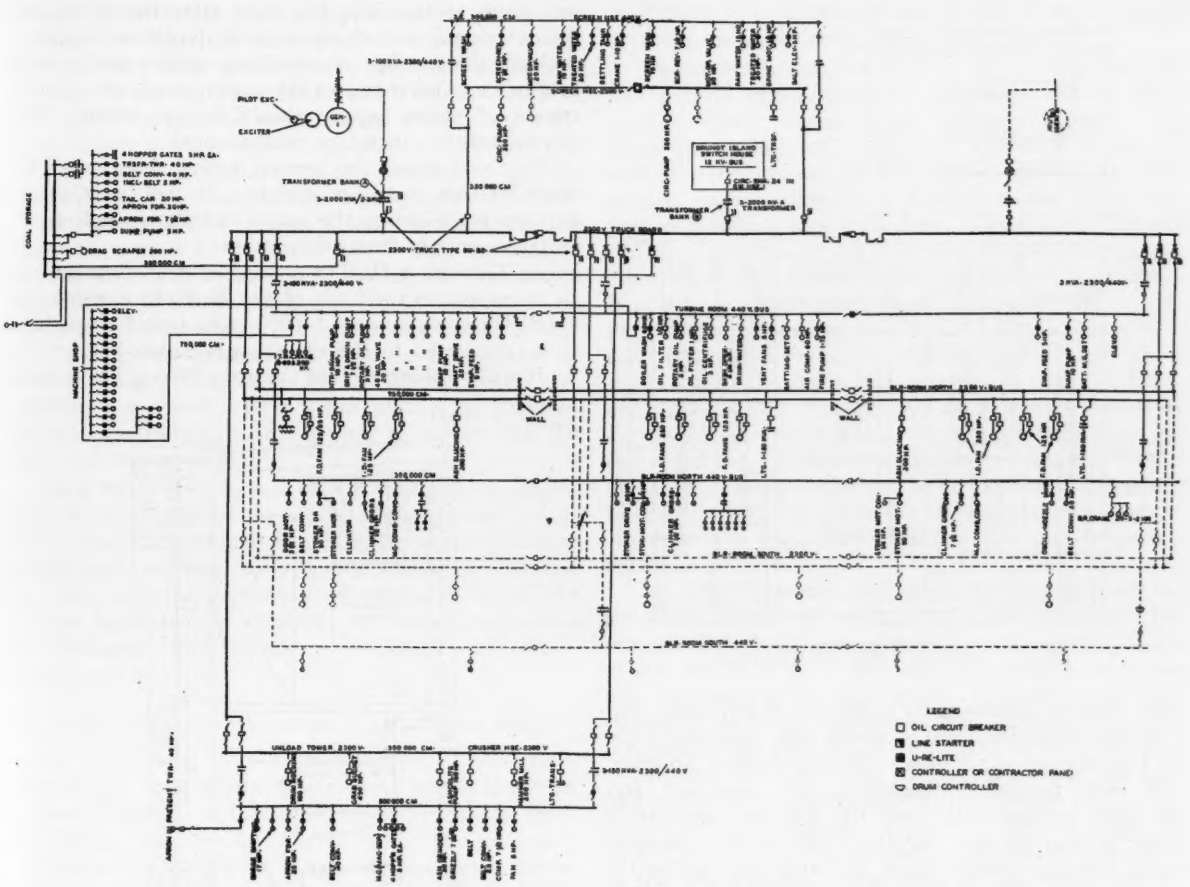


FIG. 2. GENERAL SINGLE LINE DIAGRAM—STATION POWER SYSTEM

of operation. This thought carried with it the idea of coördinating the related electrical and mechanical features of the auxiliaries into combined units of operation.

Taking the case of the circulating water system as an illustration, it will be noted that there are two circulating water pumps to serve the condenser of the first turbine unit. It was reasoned that the combined operating unit as far as the circulating water pump was concerned, consisted of the motor operated pump, together with all electrical connections from this motor to the power supply bus. As long as there is but one pump and one motor on this unit, there should be no need of more than one of each of the electrical items, such as one bus, one switch, one circuit, etc. Obviously,

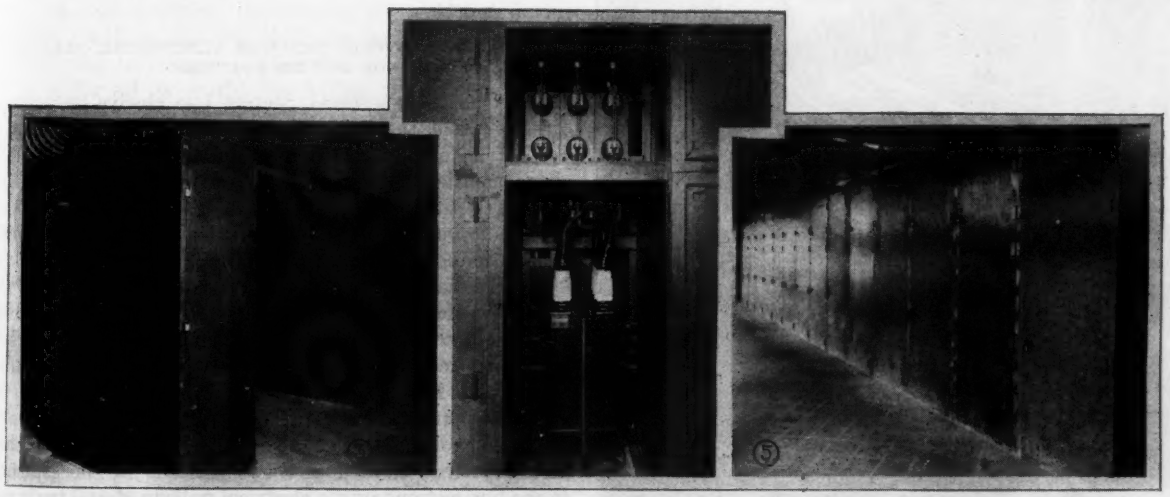


FIG. 3. 2300-V. OIL CIRCUIT BREAKER CUBICLES—SCREENHOUSE FIG. 4. INTERIOR VIEW CIRCUIT BREAKER CUBICLE—SCREENHOUSE FIG. 5. STEEL CUBICLES FOR 2300-V. OIL CIRCUIT BREAKERS, TURBINE AND BOILER ROOM GROUP BUSES

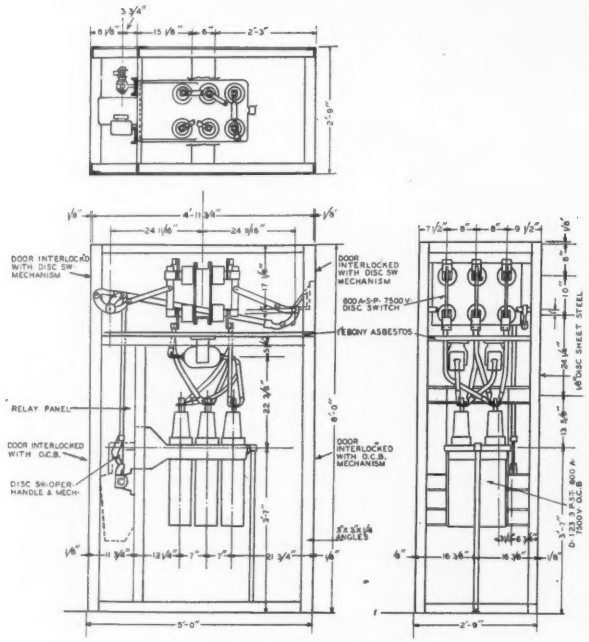


FIG. 6. SWITCH CUBICLE DETAILS

with such an arrangement a failure at any one point will render the combined pumping unit inoperative until the trouble is remedied. Such a failure, however, will only partially incapacitate the condenser and the main turbine unit, since the duplicate circulating water pump will care for the needs of the condenser up to roughly two-thirds of its rated load under the worst conditions of cooling water temperature, and to greater amounts under more favorable water temperatures. Again it was reasoned that if the second circulating water pumping unit, with its connections could be operated from a separate bus from the one supplying the first unit, that at least one-half of this pumping equipment would be maintained in service with a failure on any part of the other half. The more thought which

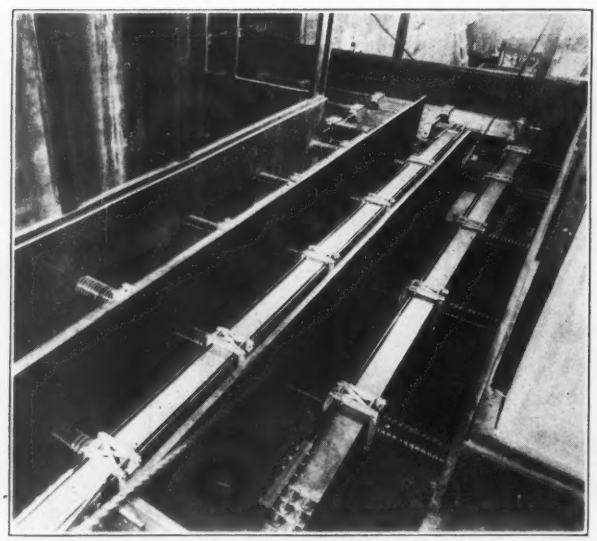


FIG. 7. GENERATOR LEADS DURING CONSTRUCTION IN ELECTRICAL GALLERY

was given to this idea the more attractive it became. By carrying it out duplication of duplicates would be avoided, the number of switching devices and circuits held to a minimum and an inherently simple and reliable system of power supply should be the result. This general scheme, therefore, was adopted.

Figure 2 shows the general wiring diagram of the entire station auxiliary system. It will be observed that the main bus on the initial installation will derive its power supply from two sources:

(A) Through a 6000-kv-a. bank of transformers connected to the leads of the 75,000-kv-a. generator.

(B) Through a second 6000-kv-a. transformer bank connected to the switchhouse 12-kv. bus.

It will be observed that the main 2300-v. bus is being

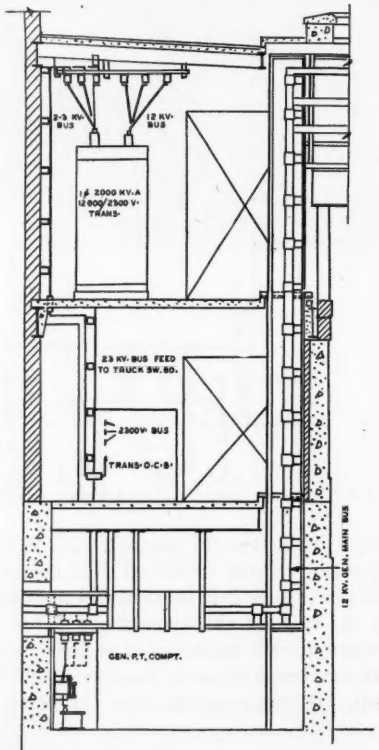


FIG. 8. CROSS SECTION THROUGH ELECTRICAL GALLERY OF POWER STATION

installed in three sections, Section 1 to receive its power directly from the transformer (A) above mentioned; Section 2 to obtain its power from transformer (B) above mentioned, and Section 3 temporarily to obtain its power through junction circuit breaker from bus Section 2, but later from transformer bank (C), which will be connected to future generator No. 2.

In the diagram, above the main buses will be observed the buses for the circulating pump and screenhouse above referred to. By reference to the previous article, it will be recalled that the circulating pumps for this station are located in the screenhouse at the water's edge, a distance of perhaps 1000 ft. from the condenser. It will be observed that the main 2300-v. bus in the screenhouse is divided into two sections to correspond to the bus sections in the electrical gallery of the turbine house.

From the main 2300-v. bus sections, it will be ob-

served that there are derived supplementary group bus sections. By observing these connections closely, it will be noted that these are not duplicate buses but group buses in the correct sense of the word, since on each of these buses are grouped combinations of auxiliary units which supply a major unit of equipment. For example, the first 2300-v. bus shown on the diagram to the left takes care of the entire coal storage system. The next supplementary 2300-v. group of buses shown below the main bus connect to the boiler room. The bus labeled bus No. 1, it will be observed, carries the fan motors required for one boiler, and bus No. 2 the motors required for a second boiler, etc. Again, a further study of 2300-v. group buses reveals that the lowest pair of buses shown provides the supply for all the station coal handling equipment. Here again, it will be observed that one bus carries certain groups of motors and the other bus another group.

Thus, while the diagram may at first appear complicated, it is complicated merely by reason of the numerous circuits, but extremely simple in the matter of actual arrangement of main buses, group buses, etc. A few cuts are included consisting of photographs of the physical equipment to illustrate the actual appearance and arrangement of the above connections and switching apparatus.

Bus Sectionalizing Breaker in a Room by Itself

The view shown at the head of this article is a photograph of the main 2300-v. bus system, which, it will be observed, consists of interchangeable, removable truck panel units. The first set of breakers shown corresponds to the main bus section No. 2, then the bus sectionalizing breaker is observed located in a room entirely by itself. Beyond the further door of this room is located the truck board for bus section No. 1. Sad experiences in various plants have emphasized the necessity for isolating the bus sectionalizing breaker in this manner. It will be observed that the term "bus sectionalizing breaker" has been used advisedly in this description instead of the more customary wording "bus junction breaker." This word choice has been adopted to emphasize the point in question. It is the writer's firm belief that in any electrical installation the isolating device should itself be isolated from the equipment which it is intended to isolate. Unless this principle is adhered to it is for all the world like having the gun locked up in the safe when the burglar arrives. On the other hand, adherence to the principle above enunciated will save the spread of trouble in the event of failures.

Figure 3 shows four of the seven switch cubicles constituting the 2300-v. bus and switch structure in the screenhouse. The switch cubicle at the left houses the bus sectionalizing circuit breaker and it will be observed that the isolation above referred to, has in this instance, been carried out merely by leaving a suitable space between this switch cubicle and the cubicle on the right and left of it. It will be observed that the buses consist of three asbestos braid flameproof cables carried in an iron conduit on top of the switch cubicles.

Figure 4 is a photograph of one of the cubicles shown in Fig. 3, except with the door open showing the circuit breaker and disconnecting switches, and general arrangement of the interior of the cubicle.

Figure 5 is a photograph of the first 14 circuit breakers on boiler group buses Nos. 1 and 2.

Figure 6 is a diagram showing the dimensional data and general arrangement of the equipment for these steel cubicles. In general, not only with regard to the truck panels but with regard to the cubicles and all switching equipment on this entire station auxiliary supply system, attention is directed to the safety features which have been embodied. These safety features will provide not only for safety in service but will also provide personal safety to the operators of the station. It will be observed particularly, that there are no live parts exposed anywhere and that all of the panels have dead fronts and backs. It will be observed that all of the doors on the front and rear of the switch cubicles are provided with padlocks and in addition to this, from the cut of the dimensional doors, it will be observed that all of these doors are interlocked with the oil circuit breaker operating mechanism so as to make it impossible to open the doors to get at the disconnecting switches or other parts of equipment until the oil circuit breaker is opened.

In order to assure the successful operation of the simplified scheme of connections herein described, the greatest care has been exercised in the design of all of the details of the system and extraordinary care has been exercised in the high grade character of the construction work during installation. To illustrate the foregoing a few cuts are also included showing the care which has been taken with respect to making the connection for the auxiliary power transformer (A) to the generator leads. Figure 7 is a photograph of a portion of the generator leads located in the electrical gallery of the power-house. This electrical gallery is located outside of and parallel to the turbine room wall and between the turbine room and the isolated phase main switchhouse, which was constructed two years ago prior to the construction of this station. It will be noted that these generator leads consist of copper bars 6 in. by ¼ in. The bars for the center conductor are arranged in the form of a square section. The four bars for the two outer conductors are arranged in the form of the letter "U," with two of the bars located on the inside toward the center conductor. Tests on the physical arrangement of the conductors for the generator leads indicated that this arrangement results in the minimum heating of the conductor when carrying the full load of this machine, which amounts to 3600 amp. at 12 kv. The above photograph was taken during the construction period and before the taping and outer housings were placed on these generator leads. After the jog in these leads, shown in the photograph, they proceed vertically upward along the wall of the electrical gallery and thence over an overhead bridge connecting the electrical gallery of the turbine house with the isolated phase switchhouse. These general conditions are shown in somewhat condensed form in the cut, Fig. 8, which shows a cross section through the electrical gallery of the turbine room.

Figure 9 is a photograph showing the physical arrangement and method of connection of the conductors from the generator main leads to the station auxiliary transformer bank (A). This photograph also shows the fault bus tap connection. The photograph shows connection to one of the generator leads with one of

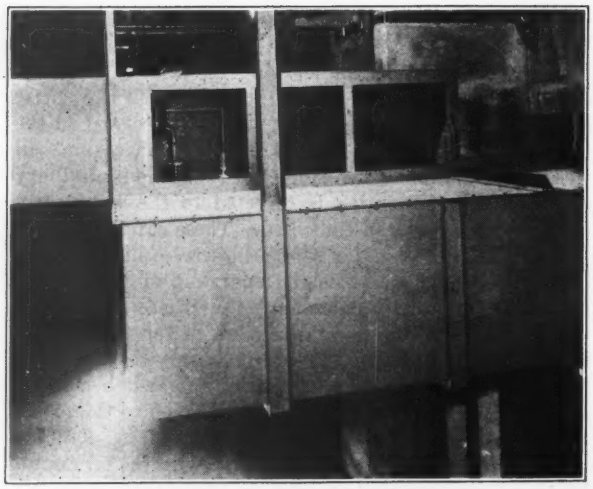


FIG. 9. METHOD OF CONNECTING TRANSFORMER BANK TO GENERATOR LEADS

the covers removed from the steel housing. The other two connections are made at the rear of the barrier shown in the photograph.

Figure 10 shows the truck type FH-206 oil circuit breaker included in the connection between auxiliary transformer (A) and the generator leads.

Figure 11 is a photograph of the three-phase reactor also included in the same leads to transformer (A). At this point, it may be well to state that some consideration was given in this instance to the omission of the oil circuit breaker and of the reactor, and of arranging to connect the transformer solidly to the generator leads and of including the transformer and its connections within the differential relay protective scheme provided for the generator. In this instance, the circuit breaker happened to be available and so it was finally concluded to employ a circuit breaker. In other installations, the direct connection of the transformer leads will probably be adopted. The advantages in the way of simplicity and in reduction of cost from such omission are obvious. It would certainly appear that by due attention to the ruggedness of the design of the transformer, and of its connections, that this part of the installation can be made inherently more reliable than that of the generator windings, so there would not appear to be any undue hazard to the generator from such a procedure.

In addition to the safeguards taken with respect to the character and arrangement of the truck board, oil circuit breaker, cubicles, etc., previously mentioned, the greatest care has been taken with respect to the design and installation of all of the accessory starting and control devices, and of the conduit and cable connections to make all features of the installation safe, simple and rugged. As an illustration, Fig. 12A is included showing a group of six starting and control devices for a similar number of 440-v. motors. In addition to the starting device, there will be observed the automatic control relays, push button stations, and particularly the safety switch connected ahead of all other control and starting devices to permit of complete deënergizing of all of the circuit from the starting device to, and including the motor. The purpose of this is further to permit of keeping alive at all times the main service lead or cable bus, as it amounts to in this installation. The safety switches are equipped with Deion arc quenchers, which are presumed to permit of opening load current if necessary. As stated above, however, in this installation these devices are used for disconnecting purposes only. Figure 12B is a view of a typical steel panel for

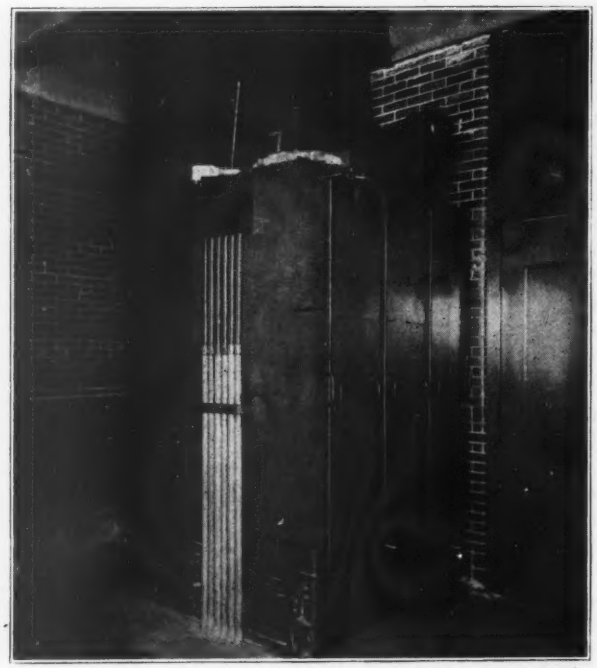


FIG. 10. TRUCK TYPE CIRCUIT BREAKER FOR CONNECTION SHOWN IN FIG. 9

FIG. 11. 12-KV. THREE-PHASE REACTOR IN CONNECTIONS SHOWN—FIG. 9

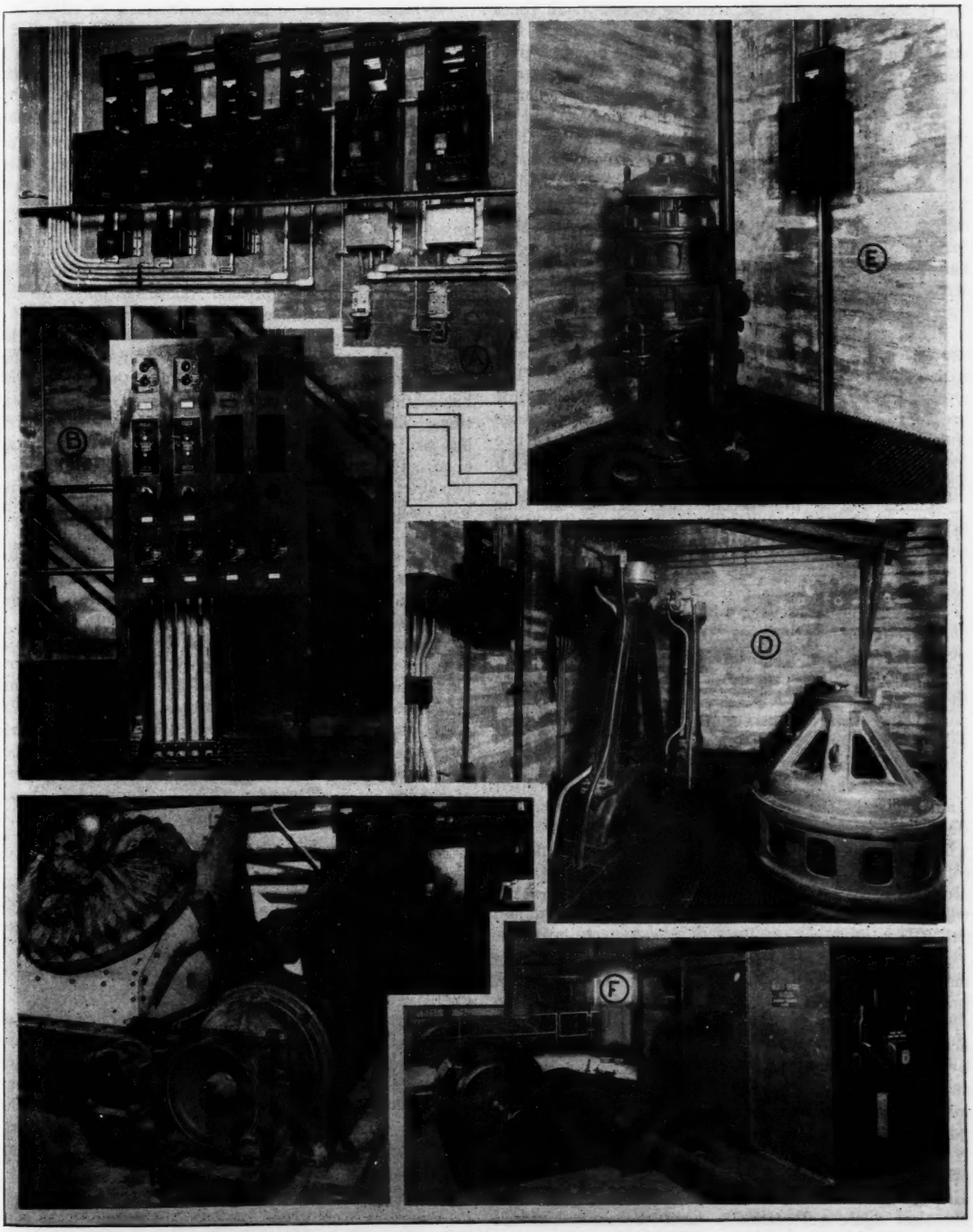


FIG. 12. VARIOUS VIEWS OF AUXILIARY EQUIPMENT AT REED STATION

A. Starting and safety switches for 440-v. equipment. B. Steel control panel for screenhouse motors. C. Totally enclosed coal conveyor motor and magnetic separator. D. Vertical circulating pump motors and valve control motors. E. Vertical motor for screen-wash pumps. F. Car elevator motor and control.

remote control of various motors and circuits in the screenhouse.

To assist further in maintaining service at all times on all buses and major circuits for auxiliaries in this station, a "voltage chasing scheme" has been adopted and applied to both the 2300 and 440-v. power systems. While attention was focused in the foregoing description, on the 2300-v. buses and connections, it will be readily observed from the general wiring diagram, Fig. 2, that similar 440-v. circuits and buses have been derived through suitable banks of 2300/440-v. transformers, and the treatment of the 440-v. circuit has otherwise been carried out in a manner similar to that for the 2300-v. system. To complete the picture of the handling of the power supply system, the following description is included, of the design and operation of the "voltage chasing scheme."

The "voltage chasing scheme" has been designed for use with two bus sections, each having a single feed and with a bus tie breaker between the two sections. The normal running order will be with the two feed line breakers closed and the tie breaker open. The voltage chasing scheme will prevent the paralleling of the two feeds, but will maintain voltage on both sections with either line out.

Should No. 1 line become deënergized, the line breaker will open automatically, the tie breaker will close, and thus No. 1 bus section will be fed from No. 2 line through the tie breaker. If under these conditions No. 2 feed should become deënergized, the No. 2 line breaker and the tie breaker would open, leaving all three breakers open. Service will be restored to both bus sections from whichever line becomes energized first. A time delay has been introduced, however, between the energizing of one bus section and the second, to permit the starting current of the motors to diminish before the second set of motors is thrown across the line with its large initial starting current demand.

In case both No. 1 and No. 2 lines become energized simultaneously, the breakers on both feeds will close, the tie breaker will remain open and normal running order will exist. In a similar manner, should No. 2 line become deënergized while operating on the normal running order, the line breaker will open and the tie breaker will close to energize No. 2 bus section from No. 1 line. Other operations are the same as described above.

Should it be desired to operate by hand control, the manual-automatic setup switch is thrown to the manual position. The breakers may then be operated by the operator to give any desired setup. Interlocks are so arranged that the two feed lines cannot be paralleled by hand control. If, after the completion of manual switching, it is desired to operate automatically, the manual-automatic switch is thrown to the automatic position and the voltage chaser will maintain service.

Any breaker may be tripped at any time, whether operating under manual or automatic control, by means of the control switch, but any breaker so tripped will not close again automatically until the control switch is reset by the operator; however, should any breaker be tripped accidentally in any manner other than through the operation of controller or overload relays, the breaker will reclose automatically except when running under normal manual control. Regardless of its previous feed, while operating under automatic control, either bus section will close in again on its regular feed if energized or through the tie breaker if not energized.

Overload protection has been provided on either bus section with feed either from the associated line breaker or through the tie. Should the overload relays on either bus section operate, the breaker feeding the bus section will open and cannot close either automatically or by hand control, until the operator has cleared the trouble.

If it is desired to take any breaker out of service for maintenance or testing, the disconnect switches are opened after tripping the breaker. The breaker in question can then be operated regardless of the position of any other piece of apparatus, and the operation of this breaker will not interfere with the operation of the balance of the system. When the disconnect switches are closed again, the breaker takes its place in the scheme as soon as the control switch is reset.

The same general scheme as outlined above can be used for the turbine room and boiler room 2300 and 440-v. system. In this case, however, there are three bus sections and two tie breakers between adjacent sections. The normal running order will be with the three bus section feeder breakers closed and the tie breakers open. The scheme will prevent the paralleling of any two lines either automatically or by hand control, but will maintain voltage on all bus sections with one line out.

The same conditions as to manual and automatic operation, overload protection, removal of breakers from service for inspection or repair, apply for this scheme as in the scheme planned for the screenhouse.

In addition to the care which has been taken with regard to the station power supply system, similar care has been exercised with regard to the character and arrangement of the various motors in the plant. In every instance, the greatest precaution has been taken to arrange the motor with suitable mechanical and electrical characteristics for the application made. Views of a few typical cases are included. Figure 12C shows the totally enclosed motor, driving belt conveyor of the main coal handling system, and this cut also gives a view of the magnetic separator.

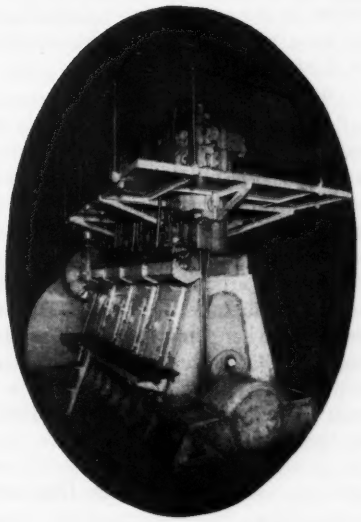
Figure 12E is a view of the two vertical type circulating pump motors in the screenhouse, and also views of the gate valve motors and their respective immediate controls.

Figure 12D is a view of vertical motor for wash pump in screenhouse showing drip hood.

Figure 12F is a view of one of the large motors together with transformer and switch starting and running control located in the top of the car elevator building, which was illustrated as Fig. 3 of the article of April 1st. Grateful acknowledgment is made to the assistance rendered by the writer's colleagues, Messrs. H. C. Hammer, F. C. Hornibrook and R. M. Stanley in the preparation of this article.

PRODUCTION of bituminous coal in recent weeks continues approximately the same as the corresponding weeks of 1928 but about 8 per cent below 1929. Stocks of coal in consumers' hands decreased 7,200,000 t. during the first quarter. Production and shipments of anthracite during April were somewhat in excess of March but are below the level of last year.

DIESEL ENGINE UPKEEP



PART III. PISTON UPKEEP IS DEPENDENT UPON OPERATING CONDITIONS OF OTHER ENGINE PARTS. HIGH TEMPERATURES COMPLICATE PROBLEM. REPAIR AND UPKEEP METHODS. WITHDRAWAL AND REPLACEMENT

BEST MAINTENANCE results are secured when pistons and piston rings are not only properly cared for directly but when other parts and functions of the engine affecting operation of the piston receive proper attention also. Conditions of operation vitally affect the life and efficiency of pistons and rings. In the preceding article, we have shown how use of improper oil, insufficient compression and incorrect spray conditions cause trouble. In Fig. 1, we see the effect of carbon accumulation.

CONDITIONS AFFECTING PISTON MAINTENANCE

Some of the direct conditions affecting piston maintenance are adequate strength to withstand the maximum combustion pressure in the cylinder and to avoid distortion, effective sealing against the burning gases in the combustion chamber and the bearing surface of the piston, proper bearing fit in the cylinder at all temperatures, good bearing properties with normal lubrication, high heat conductivity to effect rapid heat dissipation and, in the case of high speed engines, light weight to minimize inertia forces.

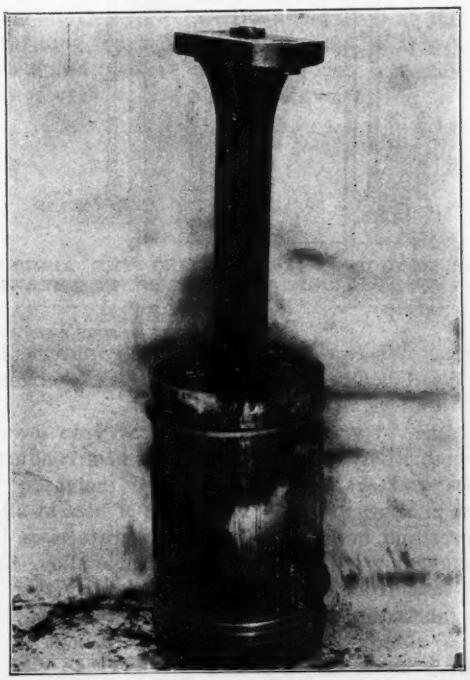


FIG. 1. CARBON ACCUMULATION ON PISTON GUMS UP RINGS CAUSING THEM TO STICK THUS PERMITTING LOSS IN COMPRESSION AND POWER

Occasional fracture, distortion and wear of ring slots are direct sources of trouble. Fracture of the piston head, which usually develops in radial cracks, may be caused by overloading or overheating. Cracks in the side which usually form circumferentially are caused by distortion or by failure of lubrication or of the cooling system resulting in piston seizure.

WELDING REPAIR METHODS

Autogenous welding is applicable to piston fracture repair if properly performed. If the fracture can be prepared as indicated in the preceding article, it is better to employ that method of V-cutting and studding. Piston welding is easier than cylinder welding because of more symmetrical disposition of metal. Heating causes metal growth which results in increasing the diameter of the piston pin hole therefore if heating must be resorted to, as when studding is not convenient, the heat should be applied, if possible, only to the portion of the piston above the hole, using four oil torches arranged symmetrically around the piston.

If the entire piston must be heated, all burned metal should be cut away by drilling and air chiselling, as before, cutting the V groove the full length and depth of the crack. If a furnace large enough is not available, a temporary furnace can be built of firebrick, wrapping asbestos paper around the wall and leaving a draft opening at the bottom. A sheet of asbestos board is laid over the top with a small opening left for draft. Charcoal is used as fuel and heating should be done slowly and evenly to a cherry red. Welding is done through a small opening in the asbestos directly over the spot to be welded. After the V has been filled up, all openings in the asbestos are covered and the piston

allowed to cool slowly before it is removed. Heat cracks in the center of the piston head may be prevented in some types of pistons by cutting a circular groove as shown in Fig. 2.

Wear of ring grooves is particularly rapid when the cylinder liner is badly worn. If only a slight ridge has been formed, it can be removed with a fine file. If the wear has been considerable, the groove may be turned out in a lathe and oversize rings fitted. It is better, however, to build up the worn portion by autogenous welding after which the groove may be machined to the original dimensions. Replaceable wearing rings are now used to take up wear. Trouble has developed in their use when they have been made too thin. A wearing ring ⅜ in. thick will work satisfactorily in a 20-in. cylinder. Tension should be given the wearing ring to cause it to spring out and lock in the groove or it should be spot welded in place.

Causes of Distortion

Distortion may be caused by driving the piston pin too hard and by pulling up too hard on the locking

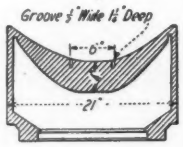


FIG. 2. METHOD OF GROOVING PISTON HEAD TO PREVENT CRACKING

screws. In either case, the effect is to spread out the skirt of the piston at the bottom in a direction parallel to the piston pin, making the bottom of the piston elliptical; distortion thus caused is perceptible even in pistons 2 ft. in diameter. Due to the infrequency of replacement of the piston pin, distortion is more likely to be found in new pistons. Distortion from this cause may be avoided by using a piston whose skirt is separated from the hot ring belt but connected to the head by struts or a sub-barrel.

Piston side clearance and distortion may be observed without removing the piston from the cylinder by clamping a short bar, having a cap screw projecting from its central point, to the face of the piston by means of large washers under cap screws, screwed into the holes intended for the piston eye bolts as shown in Fig. 3. A block of wood avoids marring the cylinder edge and a bar placed against it and the projecting cap screw serves as means to hold the piston to one side of the cylinder. A wooden wedge driven in at the bottom then permits feelers to be entered to gage the amount of clearance at any point. The feelers should have long blades in order to reach at least 6 in. up the side of the cylinder to gage the clearance where the distortion will not be great.

Where distortion is sufficient to justify repair, the piston can be dressed with a file until the desired clearance recommended by the builder is obtained. While testing and repairing the piston for distortion the rings should be left out of the piston and both piston and cylinder should be free of cylinder oil. Piston clearance records should be recorded and filed as indicated in our previous article.

Application of Alloy Pistons

Alloy pistons are substituted for cast-iron pistons, particularly where piston speeds are high, to prevent knocking at the bearings, hence wear due to sudden reversal of pressure at the end of the stroke and to provide for rapid dissipation of heat. Aluminum, copper, nickel and iron are elements used in combination to provide a material of ample strength that combines high heat conductivity and low weight and permits operation without resort to water or oil cooling. The heat conductivity of aluminum alloys is over four times that of

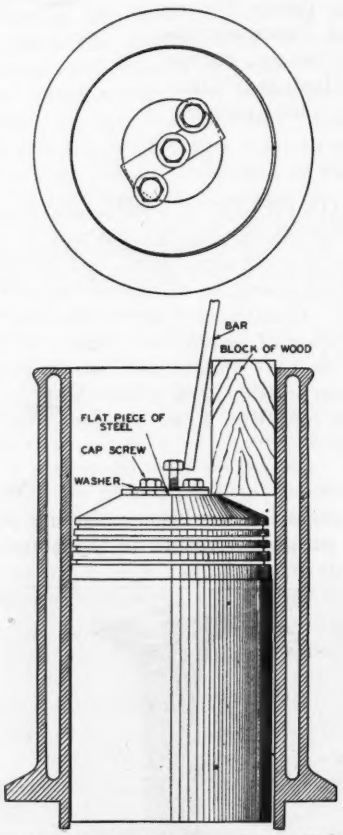


FIG. 3. METHOD OF DETERMINING THE AMOUNT OF CLEARANCE AROUND THE PISTON BY MEANS OF FEELERS

cast iron. Where change in operation requirement presents the difficulties mentioned they are overcome by resort to alloys in place of cast iron.

Presence of graphitic carbon in cast iron lowers its heat conductivity. This reduction in heat conductivity becomes greater as the temperature increases, while aluminum alloys are good conductors of heat at all temperatures and improve as the temperature rises. Cast iron is about twice as heavy as a suitable alloy. Alloys absorb heat from the hot gases less readily than iron, hence lubrication and bearing qualities are improved. But, as aluminum alloys have a coefficient of heat expansion about 120 per cent greater than cast iron, provision is made to reënforce the alloy metal with steel bands cast into the alloy skirt.

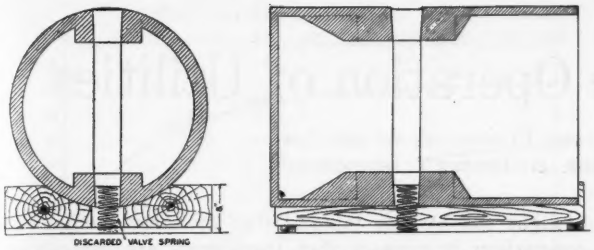


FIG. 4. DEVICE FOR REGRINDING TAPER PISTON PIN TO PROPER FIT

Piston pins, after removal from the piston, should be examined for wear by the use of a micrometer and should be checked for clearance after having been placed in the connecting rod box by use of feelers, proper record being kept of the condition in which the pin was found and that in which it was left. Where a taper, which has been pounded out of round, is used it may be reground to proper fit by means of the device shown in Fig. 4. The spring, which is set under the piston just below the pin, keeps the pin raised when the pressure is released, better distributing the emery and oil which are used as abrasive.

Replacement of a piston pin due to excessive wear or possible fracture should be taken up with the manufacturer but in an emergency a temporary pin may be made quickly of cold rolled shafting and casehardened by rubbing its surface while red hot with potassium cyanide and plunging in water. Lapping to size after this hardening process may be done with strips of emery cloth, finishing with emery paste in place.

Piston Inspection and Cleaning

Pistons are usually withdrawn at the top of the cylinder after removing the head and its attachments. Some pistons are withdrawn through the engine base. In this latter case, it is well to avoid marring the piston by providing wood blocks and bagging for this purpose. The simplest method of withdrawing a piston is by means of eyebolts and sling as shown in Fig. 5. When removing or replacing a piston, care should be taken not to damage its cylindrical surface.

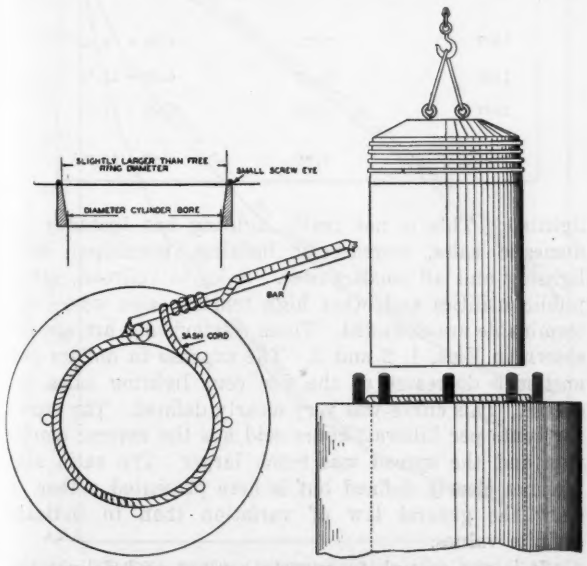


FIG. 5. SASH CORD IS USEFUL TO COMPRESS THE PISTON RINGS IF RING GUIDE IS NOT AVAILABLE

After removal from the cylinder, the piston should be cleaned, by scraping with copper or brass plates—emery cloth should not be used. The rings should then be removed and all the carbon cleaned out of the ring grooves. All of the rings that are loose may be removed by lifting the ends and slipping strips of sheet metal under them and working these strips around until the ring is supported at four points, free of the grooves. They may then be slipped free of the piston. If some of the rings are stuck, they should be swabbed with kerosene oil and tapped with a hammer on a hard wooden block. If this does not serve to loose them, immersion in a vat of boiling lye water will almost surely do so.

If time does not allow this course, the sticking rings should be broken out with a cold chisel. The piston should then be cleaned thoroughly with kerosene oil and examined for cracks and imperfections. In removing the rings, they should be kept in order so that they may be returned to the same grooves they had occupied previously. Worn, marred or bent rings should be replaced. The oil hole of the piston pin should be cleaned out.

Piston Replacement Methods

In replacing the piston, the ring grooves should be lubricated and the inside of the cylinder swabbed with oil. The piston body is more easily kept clean and handled most readily if it is not oiled. Sash cord with a smooth finish, loosely fastened at one end to one of the cylinder studs, passed around the piston and ring inside of the stud circle and put under tension by a bar as shown in Fig. 5 serves as well as a makeshift method of entering the rings one by one into the cylinder but the best method is by use of a ring guide, Fig. 5, which is usually supplied by the manufacturer. After the piston is in its lowest position, it is well to operate the cylinder lubricator by hand to be sure the piston pin oil holes are filled with oil. Since the piston pin is located in a belt of high temperature and spread of lubricant is due to oscillation rather than rotation of the pin, danger of seizure, if the lubrication fails, is certain.

Aerial Passenger Tramways for America

Announcement is made by the American Steel and Wire Co., a subsidiary of the United States Steel Corporation, that it has been appointed sole licensees of the Bleichert and Bleichert-Zuegg Systems for America.

This makes available in this country an efficient system of aerial tramways for passenger transportation, a means of travel hitherto largely confined to Europe. By this system the highest mountain can be climbed or the deepest river crossed in perfect safety with the thrill of passing through space at high speed and the advantage of unrestricted vision of surrounding countryside. In a few minutes, distances are covered in comfort that would otherwise require hours or days with considerable hardship.

The company will have its offices for information in regard to this transportation system at 208 South La Salle Street, Chicago.

Physical Factors in the Operation of Utilities

PART III. COSTS OF DELIVERING THE ELECTRICITY TO THE CUSTOMER FROM THE CENTRAL STATIONS. BY ROBERT T. LIVINGSTON*

THIS ARTICLE IS the third of the series presenting a study of the operating costs and principal physical factors of operation of the electric utilities of New York State. The data from which these studies were made were taken from Volume II of the Annual Reports of the Public Service Commission of New York State for the three years, 1917, 1922 and 1927. These three years were selected so that changes over the 10-yr. period could be observed and because 1927 is the latest report which has been printed. The first article appeared in the March 1 issue of Power Plant Engineering and explained the methods used in the statistical analysis and defined the terms. In this issue, also, the studies of the load and use factors and per cent electricity sold were presented. The second article appearing in the May 1 issue carried the study of the loads per customer and the costs of producing the electricity. This third and last article discusses the costs of delivering the electricity to the customer from the central station.

TRANSMISSION AND DISTRIBUTION

In the standard system of accounts used by New York State, the transmission and distribution accounts include all the costs of operation and maintenance of the high tension lines and the low tension networks; from the outgoing lines at the power stations to the consumer's fuse box. Theoretically the transmission line should be considered as an extension of the power station bus bar, hence the transmission costs should be added to the station costs for the total costs of producing electricity and the distribution costs should be considered separately. Due to the vagueness of definition and the latitude allowed in the standard system of accounts, this is impossible. There are a number of accounts, particularly those appertaining to the substations where the operating company can charge the expenses either to transmission or distribution and while one company may charge such expenses entirely to distribution, another company may split them up evenly or any other division that the management may see fit. In this study, therefore, the transmission and distribution costs have been added together and also those costs called utilization—or street lighting expense. The inclusion of this third class is without doubt incorrect but it is here put in mainly for convenience and because the amount is so small that it will make no great difference.

These costs were analyzed in a similar manner to the way the production costs were analyzed in the previous article; on a basis of dollars per customer per year, on a basis of cents per kilowatt-hour sold and lastly as a ratio to the operating ratio. These comparisons are shown in Table I. Only the median and the range are here presented because the spread was so wide that no definite mode could be obtained. The principal thing brought out by this table is that by every method of comparison it appears that these costs are increasing and increasing materially. Not only that but, as the median goes up, the range or spread is getting larger. As with production cost, it was found that there was no definite law of variation with size of company, number of customers or kilowatt-hours sold. The only factor which appears to have any certain influence upon these costs is the per cent of the total sales which are lighting. This is not really lighting but includes all domestic sales, commercial lighting, municipal steel lighting and all small power. Sales to railroad, other public utilities and other high tension sales where determinable are excluded. These relationships are clearly shown in Figs. 1, 2 and 3. The expense in dollars per customer decreases as the per cent lighting sales increase. This curve was very clearly defined. The curve for cents per kilowatt-hours sold has the reverse condition and the spread was much larger The ratio also was not clearly defined but is here presented rather to show the general law of variation than to indicate definite values.

TABLE I. TRANSMISSION AND DISTRIBUTION COSTS

YEAR	MEDIAN	RANGE
	$/YEAR/CUSTOMER	
1917	$4.80	1.50 - 7.50
1922	6.40	2.00 - 10.00
1927	7.30	2.00 - 10.00
Period	6.20	2.50 - 7.50
	¢/KWHr. SOLD	
1917	0.31	- 0.45
1922	0.36	0.10 - 0.45
1927	0.39	0.15 - 0.70
Period	0.34	0.10 - 0.45
	RATIO TO REVENUE	
1917	7.25	4.50 - 9.00
1922	8.80	4.50 - 11.50
1927	9.50	7.00 - 11.00
Period	7.75	4.50 - 10.00

It is not enough to operate a plant and deliver the electricity, which the customer requires to his meter.

*Assistant Professor Mechanical Engineering, Columbia University.

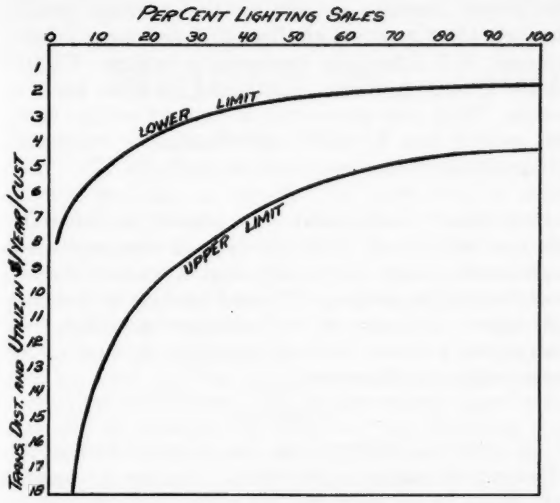

PER CENT LIGHTING SALES
0 10 20 30 40 50 60 70 80 90 100
LOWER LIMIT
UPPER LIMIT
TRANS. DIST. AND UTILIZ. IN $/YEAR/CUST
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

FIG. 1. TRANSMISSION, DISTRIBUTION AND UTILIZATION IN DOLLARS PER YEAR PER CUSTOMER AGAINST PER CENT LIGHTING SALES

The responsibility does not end there. The consumer's meter must be read, his account record kept and bills must be sent out. It is unfortunately true that it is often necessary to send out several bills and perhaps eventually a bill collector. All such costs as these which are incident to selling the product and collecting the revenue are termed Commercial Costs. New Business Costs, as the name implies, includes all those costs which are incurred due to the effort to obtain new business. Sales campaigns for selling appliances, the rent, light, labor and expense of the show room and the advertising literature sent to the customers are all included under this heading. The analysis of these costs is presented on the two bases, dollars per year per customer and

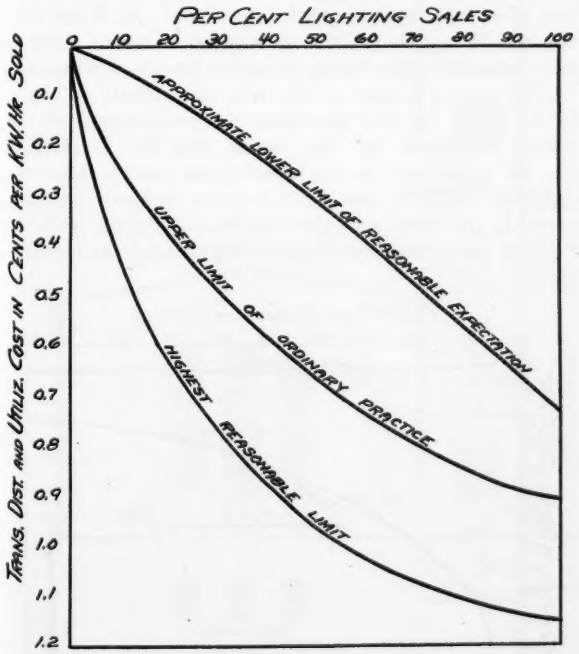

PER CENT LIGHTING SALES
0 10 20 30 40 50 60 70 80 90 100
APPROXIMATE LOWER LIMIT OF REASONABLE EXPECTATION
UPPER LIMIT OF ORDINARY PRACTICE
HIGHEST REASONABLE LIMIT
TRANS. DIST. AND UTILIZ. COST IN CENTS PER K.W.HR. SOLD
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2

FIG. 2. TRANSMISSION, DISTRIBUTION AND UTILIZATION IN CENTS PER KW-HR. SOLD AGAINST PER CENT LIGHTING SALES

TABLE II. COMMERCIAL AND NEW BUSINESS

COMMERCIAL COST/CUSTOMER

YEAR	MODE	MEDIAN	RANGE
1917	1.20	1.82	1.00 - 2.20
1922	1.80	1.80	1.20 - 3.00
1927	2.20	2.30	1.40 - 2.80
All	1.90	1.82	1.00 - 2.60

NEW BUSINESS RATIO

YEAR	MODE	MEDIAN	RANGE
1917	0.60	1.00	0.20 - 0.80
1922	0.70	0.80	0.20 - 1.00
1927	1.30	1.60	0.40 - 1.40
All	0.60	1.10	0.20 - 1.40

per cent of operating ratio. As there is no apparent relation between these costs and the kilowatt-hours sold, this third method was omitted.

A careful analysis showed that the commercial costs per customer was a better guide than the ratio and this is presented in Table II. The commercial ratio has a wide range running from 0.5 to 3.75 per cent with an indefinite mode at 2.35 per cent. On the other hand, it was seen that the New Business Ratio was a better grade than the cost per customer and this ratio is also presented in Table II. The New Business Cost per customer varies from 30c to $1.00 per customer with a mode at about 60c per customer. As with the transmission and distribution costs, the commercial and new business costs have increased steadily over the period under consideration.

General and Miscellaneous Cost

In order that a business function properly, it is

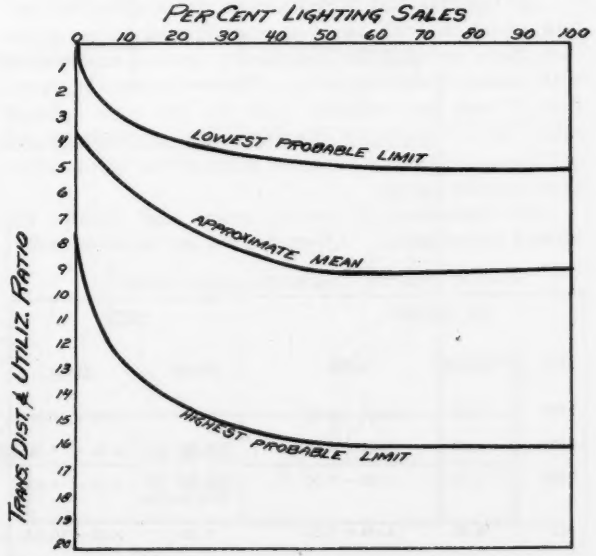

PER CENT LIGHTING SALES
0 10 20 30 40 50 60 70 80 90 100
LOWEST PROBABLE LIMIT
APPROXIMATE MEAN
HIGHEST PROBABLE LIMIT
TRANS DIST. & UTILIZ. RATIO
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

FIG. 3. TRANSMISSION, DISTRIBUTION AND UTILIZATION RATIO AGAINST PER CENT LIGHTING SALES

TABLE III. GENERAL AND MISCELLANEOUS COSTS

	PER CUSTOMER			RATIO		
YEAR	MODE	MEDIAN	RANGE	MODE	MEDIAN	RANGE
1917	-	6.50	3.00 - 7.50	-	9.25	4.00 - 11.00
1922	-	7.30	4.00 - 7.50	-	9.33	4.00 - 13.00
1927	-	7.80	4.50 - 8.50	-	9.50	6.00 - 14.00
All	-	7.25	4.50 - 8.50	9.50	9.25	6.00 - 11.00

necessary that it be managed and all those costs of management and other costs which cannot be definitely charged elsewhere are termed General and Miscellaneous Costs. This includes the salaries and expenses of the general officers and general office expenses, the costs of running the main office, legal expenses, insurance and all similar expenses.

Table III presents the analysis of these costs on the two general bases, dollars per year per customer and as a ratio. Again the mode could not accurately be determined because the spread was so wide. The median of the customer cost shows a definite increase over the period of years under consideration but this increase is not so apparent on the ratio basis. It is impossible to draw any general conclusions about this cost because, due to the different systems of management in practice, similar companies may have materially different costs. A company which is a member of an association of operating companies under the control of a management or holding company presents an entirely different picture from a similar company operating as a single unit. In the first case, the company will have the services of high class technicians applying such time as is required to that company and then working for one of the other associated companies at other times. In this manner, many economies of operation may be obtained that the independent company cannot match because they cannot afford the full time employment of such high class men. In a similar manner, economies due to group buying engineering and construction may be affected by the holding company control.

The General and Miscellaneous Ratio shows no certain variation with the per cent lighting sales except that there seems to be a tendency toward an increase with increased lighting sales. Figure 4 shows the variation of cost per customer with the per cent lighting sales. In this instance, the curves are not definite and are presented only to show the trend of variation rather than specific values.

All equipment in service wears and repairs are termed maintenance. All such costs are included under the proper heading in this or the previous article; however, after a period of time, it is no longer possible to repair and it becomes necessary to replace. Utilities set up a reserve which is intended to cover such renewals. Each year an amount is charged to this reserve and such a sum is called amortization or retirement. The analysis of this cost is shown in Table IV. There seems to have been little change in this cost over the period under consideration. It seemed probable that this cost would vary with the type of company under consideration; that is to say, that a hydro company would charge an entirely different amount to amortization than a company which purchases its energy. Investigation, however, did not bear this out and no differentiation was discovered.

TABLE IV. AMORTIZATION COSTS

	PER CUSTOMER		RATIO	
YEAR	MEDIAN	RANGE	MEDIAN	RANGE
1917	3.90	1.00 - 5.00	6.00	2.00 - 10.00
1922	4.30	1.00 - 6.00	6.00	3.00 - 7.00
1927	4.10	1.00 - 7.00	6.00	3.00 - 7.00
All	4.00	1.00 - 7.00	6.00	2.00 - 10.00
	Mode = $2.80		Mode = 4.80%	

Summary

In order to illustrate the use of these factors, the following summary is presented. Assume a company with about 85 per cent lighting sales. The revenue per customer will then be $58.00 per year.

	Cost Per Customer	Ratio (Per Cent)
Production Cost	$22.00	40.0
Trans. & Dist.	3.50	9.0
Commercial	1.90	2.4
New Business	.60	0.6
Gen. & Miscel.	7.25	9.5
Amortization	2.80	4.8
Total	$38.05	66.3 = $38.50

The utility will then average $19.75 from each consumer. From this he must pay taxes which will vary from 8 to 10 per cent of the operating revenue, which leaves a balance of $14.50. It is necessary to pay bond interest, preferred stock dividends and set up reserves out of this as well as to pay common stock dividends. It has generally been allowed that 8 per cent is a fair rate of return on a companies rate base. At 8 per cent this $14.50 represents an investment of about $180.00 per customer. This figure is rather low than otherwise.

The author wishes to take this opportunity to thank J. A. Stack for his assistance in preparation of the curves submitted in this series and E. F. Wilson for his criticisms of the conclusions drawn and the statistical methods used. It is to be realized that this study is not final nor the conclusions drawn definite. Further research may disclose discrepancies and differences.

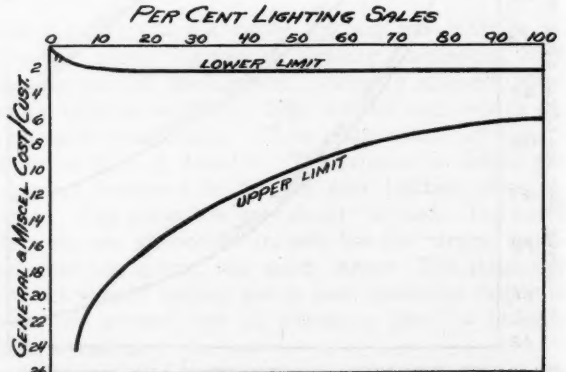

PER CENT LIGHTING SALES
0 10 20 30 40 50 60 70 80 90 100
LOWER LIMIT
UPPER LIMIT
GENERAL & MISCEL. COST/CUST.
2 4 6 8 10 12 14 16 18 20 22 24 26

FIG. 4. GENERAL AND MISCELLANEOUS COST PER CUSTOMER AGAINST PER CENT LIGHTING SALES

Heating and Ventilating Delray No. 3

AIR-SWEPT WINDOWS AND CEILING TO PREVENT SWEATING, USE OF GENERATOR COOLING AIR AND RADIATION TAKING SUPERHEATED STEAM. BY SABIN CROCKER

SUMMER conditions for ventilating the entire power house are shown in Fig. 1. The main turbine room is cooled by opening ventilating sash in the large windows on three sides of the room. When this does not afford sufficient cooling effect by natural circulation, heated air in the upper part of the room is drawn off through a duct running lengthwise of the turbine room in a monitor on the roof. This in turn causes more fresh air to flow in through the windows, thus sweeping out overheated air in the upper part of the room. The duct on the roof leads to exhauster fans located in the auxiliary bay fan room, which discharge to outdoors in summer or to the boiler house in winter. Air enters the roof duct through an adjustable slot made in sections so that the ventilating effect produced in different parts of the room is subject to control.

The auxiliary turbine room between the main turbine room and boiler house, is cooled by a set of fans which force in cool air through registers located in the side wall of the room. Another set of fans forces filtered fresh air through ducts leading to the generators for cooling them. This air escapes into the auxiliary turbine room and then is removed by the large exhauster fans along with air which entered through the wall registers. The capacity of the wall register sets is sufficient to provide five air changes per hour in the auxiliary turbine room, and that of the generator cooling sets twenty-five air changes, making a total of thirty air changes per hour which can be forced into this room.

As shown in Fig. 1, the same set of four 100,000-c.f.m. exhauster fans serves to remove overheated air from both the main and auxiliary turbine rooms. Air for cooling the auxiliary generators is drawn into the fans through filters of the surface type moistened with oil. Forced ventilation of the auxiliary turbine room in summer is essential, since it is located in a long narrow pocket having windows in the extreme ends only.

In ventilating the boiler house, use is made of air intended for combustion while on its way to the forced draft fans supplying the boilers.

WINTER CONDITIONS

Winter operation of the ventilating system in conjunction with the direct heating system is shown in Fig. 2. In winter, the ventilating system is used (a) as a means of sweeping out moisture-laden air to prevent condensation on the turbine room ceiling and windows and (b) to furnish tempered air to the auxiliary turbines and the auxiliary turbine room.

Actual heating of the building is done with direct radiation placed around the exposed walls of turbine room, condenser room, and boiler house mezzanine and

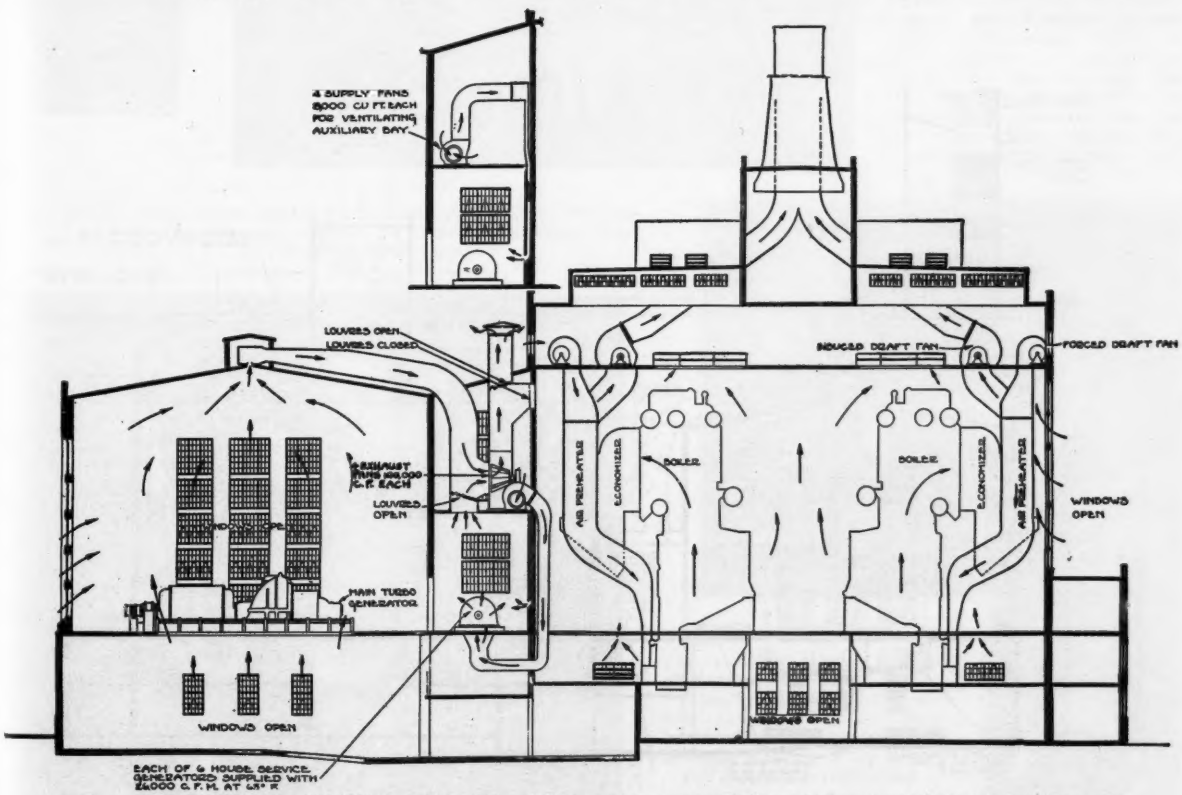


FIG. 1. OPERATION OF VENTILATION SYSTEM IN SUMMER SHOWING RECIRCULATION IN AUXILIARY BAY

operating floors. The amount of direct radiation installed is based on past experience in similar plants rather than on computed heat losses.

The problem mainly is one of installing sufficient radiation near the operators to give them a satisfactory sensation of radiated warmth, irrespective of the average room temperature, at the same time offsetting objectionable down drafts and the proximity of cold equipment. Direct radiation has been used for this purpose, both because of a lack of concentration of the heating load and because of the localized results wanted.

Window Sweeping System

In the main turbine room, the ventilating system for the ultimate plant will consist of four window sweeping sets arranged to draw in fresh air from outdoors through heaters and discharge this air, after heating to 120 deg. F., through ducts leading to slots just inside and below the turbine room windows. This provides a curtain of heated air for each window, thus preventing condensation and frosting on the windows and at the same time furnishing a supply of air to sweep the turbine room ceiling and prevent sweating there.

Summary of the surface and steam requirements of the direct radiation and ventilating sets is given in the table. The figures given are for the ultimate plant, containing six 50,000-kw. main units and six 4000-kw. auxiliary turbine-generators.

General Features of Heating System

Steam for building is extracted from the house service turbines under normal conditions, with a reserve connection through reducing valves from the plant saturated steam header when bled steam is not available.

SUMMARY OF RADIATION AND STEAM REQUIREMENTS

	Square Feet Direct Radiation	Pounds of Steam Per Hour
Heating System:		
Turbine House	15,500	3,875
Boiler House	14,500	3,625
Total	30,000	7,500
Ventilating System:		
Window Sweeping		5,000
Auxiliary Bay		11,000
Total		16,500
Heating Plus Ventilating		
Heating	30,000	7,500
Ventilating, Equivalent Direct	66,000	16,500
Total	96,000	24,000

Pressure in the turbine stage from which steam is bled varies from eight pounds gage at quarter load up to 75 lb. gage at rated turbine load.

Considerable superheat is present in the bled steam coming from the auxiliary turbines, enough in fact to give a total temperature slightly above 450 deg. F. at rated load on the low-pressure side of the pressure regulator at the bleeder outlet on the turbine.

Drip and return trap are of the corrugated bellows type using water vapor as the expansive medium, and put together with high temperature solder which can withstand 450 deg. F. Steam in the radiators apparently behaves much the same as saturated steam at the same pressure.

Acknowledgment is made for illustrations and data in this article to Heating, Piping and Air Conditioning, which based the article on notes of an illustrated lecture given before a meeting of Michigan Chapter A. S. H. & V. E.

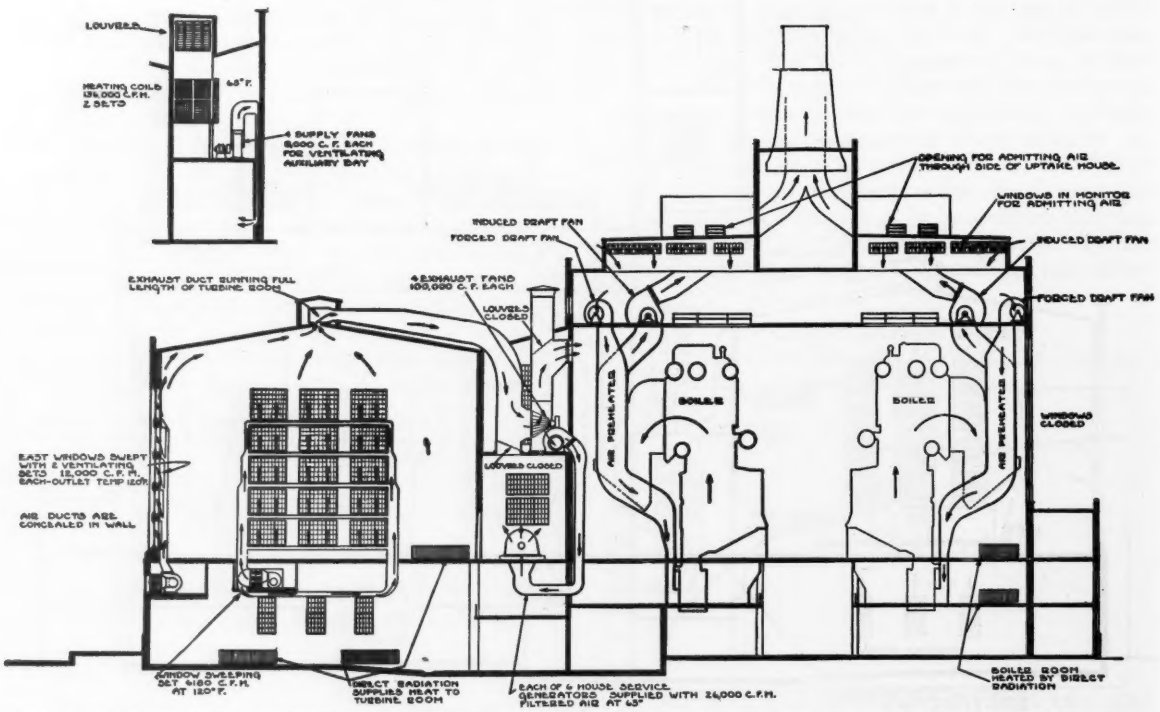
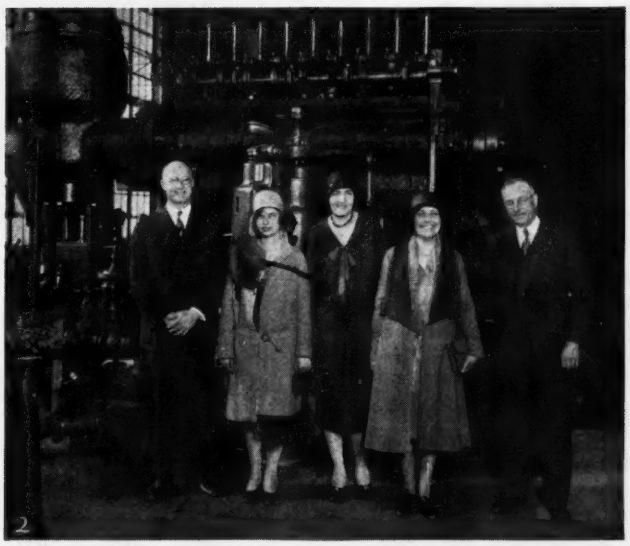


FIG. 2. OPERATION OF VENTILATION SYSTEM IN WINTER SHOWING WINDOW SWEEPING IN TURBINE ROOM

Women of Nebraska Power Company Christen New Turbine



WOMEN HAVE long been accorded the honor of christening ships but it is something new to have them perform this function in placing a steam turbine in service. This, however, occurred on Monday, April 6, at Omaha, Nebraska, when "Golden Jubilee," a new 25,000-kw. unit, was christened and dedicated by the Women's Division of the Nebraska Power Co. The machine was named by Margaret Southard in commemoration of Light's Golden Jubilee. Miss Southard christened the unit with a bottle of Missouri River water. As the bottle broke against the name plate, Alma Jane Hogue opened the throttle that started the turbine on its career.

In the accompanying photographs are shown the principals in the ceremony. "It is a great honor for the Women's Division to have the distinction of dedicating 'Golden Jubilee'" said Martha Bahlsen, president of the Women's Division. "It is the first turbine in our power station that has been christened by a girl. We hope it is not the last."

President Davidson of the Nebraska Power Co. gave a short address. "We are all proud of this unit," he said. "We appreciate the interest of the Women's Division in our efforts to serve customers and it is only fitting that they christen and dedicate this turbine."

In Fig. 1 Miss Hogue is shown opening the throttle. Fig. 2. Mr. Davidson, Martin Bohlsen, Alma Jane Hogue, Margaret Southard and Lee Ruff. Miss Bohlsen is shown placing the name plates on the unit in Fig. 3, while in Fig. 4 Miss Southard is seen just before she broke the bottle against the turbine casing.

The women of the Nebraska Power Co. were very enthusiastic about the part they played in these dedication ceremonies. The efforts of the women in Public Utility organizations are important but very often are not appreciated or recognized. It seems only fair that in functions of this character they should be permitted to play a part.

Fig. 1. Miss Hogue opening the throttle. Fig. 2. Pres. Davidson, Lee Ruff, chief eng., and members of Women's Division. Insert at left shows name plate.

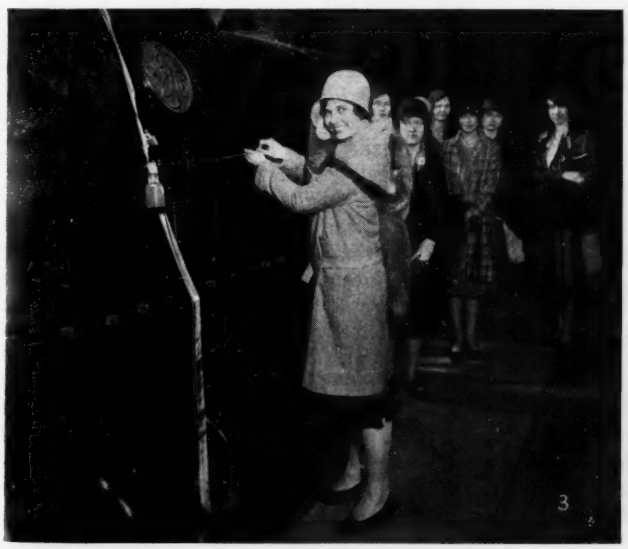


Fig. 3. Miss Martha Bohlsen placing the name plate, "Golden Jubilee," on the side of the turbine casing. Fig. 4. Miss Southard shown holding the bottle of Missouri River Water just before the christening.

Powerton Makes Record for Economy

AVERAGE SIX MONTH PRODUCTION AT 12,610 B.T.U. PER KW-HR. RECORD FOR ECONOMICAL POWER PRODUCTION

IN AN ADDRESS delivered at the annual dinner of the Western Society of Engineers in Chicago, May 22, Wm. S. Monroe, retiring president of the Society and president of Sargent and Lundy, Inc., presented figures on the operation of stations in the Chicago district and announced an average heat rate for Powerton station for the past six months of 12,610 B.t.u. per kw-hr. This remarkable record in economical power production is the result of many years of development

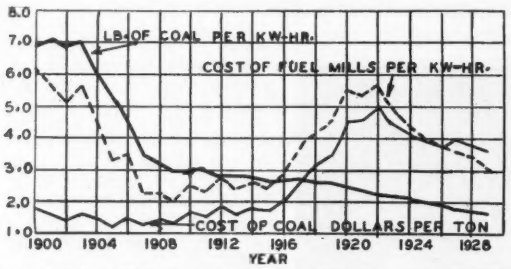


FIG. 1. COAL CONSUMPTION PER KW-HR. AND COST OF FUEL, COMMONWEALTH EDISON CO.

in the various stations of the Commonwealth Edison Co. and the allied companies in the Chicago district. It was the development of the superpower system of this district which Mr. Monroe selected as the subject for his address.

Although the first electric company operating under Edison patents in Chicago was organized in 1881, the first commercial distribution of electric energy really began with the organization of the Chicago Edison Co. in 1887. That was 43 yr. ago and for all but five years of that time the development of industry has been under the leadership of Samuel Insull. He has built up in the Chicago district one of the largest and most important and probably the most complete and comprehensive electric power systems that exists in the world today.

Mr. Monroe described the development of this system, step by step from the old Adams Street station, a noncondensing, high-speed engine driven plant where coal was delivered by wagon, to the great State Line and Crawford Avenue stations of today. The building of the Harrison St. station and the construction of the first 4500-v. transmission line in 1897 was really the beginning of the "Superpower" development in the Chicago district. The word had then not been invented, but the idea was there. "Superpower" really means the building of larger and more efficient power stations in strategic locations and extending the area of distribution by means of transmission lines and substations.

Since that time, progress has been continuous; as station after station was added to the system, new developments and improvements were incorporated in their design and the economy of the system increased. This part of the story is familiar to all power plant men and this part of Mr. Monroe's address need not be presented in detail here. Of greater interest are his remarks regarding the operation of State Line and Powerton stations.

It was shortly after the war that Mr. Insull began to feel that the city of Chicago could not depend indefinitely on plants within the city for its supply of electric energy and that the industrial districts which were rapidly growing up around the city would have to be tied in to the large plants in Chicago for maintenance of an adequate power supply. Calumet and Crawford Avenue stations were the last large stations to be built within the city limits proper. Crawford is now operating on about 14,600 B.t.u. per kw-hr. and has six cross compound turbine units of 424,000-kw. total capacity.

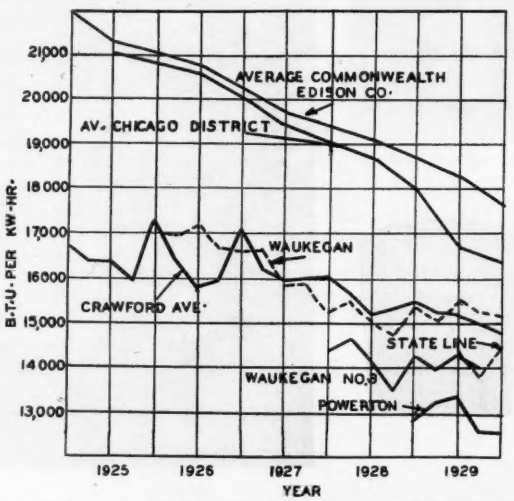


FIG. 2. HEAT RATE B.T.U. PER KW-HR. CHICAGO DISTRICT 1924-1929

In December last, the Crawford Ave. Station had an output of over 200,000,000 kw-hr. for the month. This output Mr. Monroe believed to be a world's record for one month, although in point of size, several stations are larger than Crawford.

The site of the State Line Station on the lake shore, just over the Indiana state line, was secured in 1922. About that time, also, there was some discussion in regard to building a plant on the Illinois River near the coal fields to transmit into the Chicago district, and to take care of the rapidly growing power needs of the northern and north central parts of the state. It was apparent that a large proportion of the energy from that plant would have to be transmitted into the Chicago district, and it was a question whether power could be generated 150 mi. from Chicago and transmitted into the city at a less over-all cost than generating it in the city. It was the same question that is involved in most superpower enterprises: Is it cheaper to transmit energy electrically or pay the freight on coal? The first reports were made in 1924 and 1925 and from the

figures that were then made, it seemed to be a very close balance; but the value to the Chicago power system as well as to the power supply of the whole northern part of the state, of having a large and efficient power station between Chicago and Springfield led to building what we now call the Powerton station, located on the Illinois River, twelve miles south of Peoria, with a two-circuit 132,000-v. tower line to Joliet and connecting into the Chicago system.

It is interesting to study the improvement in fuel economy of the Chicago district as a whole and the effect of the newer stations upon this economy. In Fig. 1 is shown a diagram showing the fuel economy since 1900.

It shows first the average pounds of coal per kw-hr. in the Chicago stations. Notice the very rapid decline in the pounds of coal per kw-hr. for the six or seven years after Fisk Street Station first went into operation. In 1911 the consumption was 3 pounds per kw-hr. Since then the decline has not been so rapid, but it has been

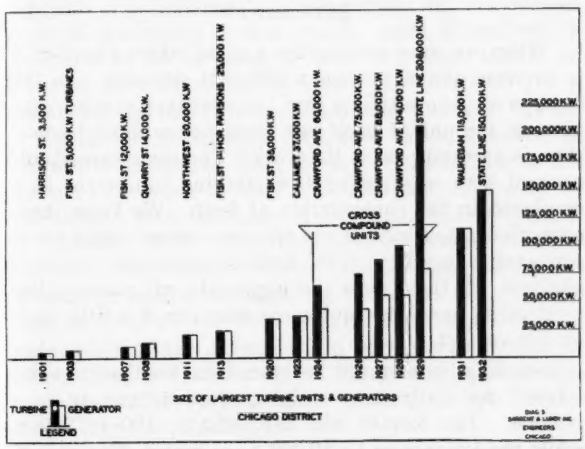


FIG. 3. SIZE OF LARGEST TURBINE UNITS AND GENERATORS IN THE CHICAGO DISTRICT

quite continuous, until this year the average consumption is 1.7. This diagram also shows the cost of coal in dollars per ton and cost of coal per kw-hr. It is interesting to note how the operating costs went up during the war period with the rapid rise in cost of coal, and fell off with the fall in cost of coal since 1922.

Figure 2 shows the improvement in fuel efficiency since 1920 in a more complete way. The upper line of this diagram gives the average fuel efficiency of the power stations in the city of Chicago from 1920 to 1929. It is given in B.t.u. per kw-hr. instead of in pounds of coal per kw-hr. The coal burned in the Chicago District averages very close to 10,000 B.t.u. per lb., but since 1920 we have figured plant efficiency in B.t.u. rather than in pounds of coal, which is more accurate, though it is not a final measure of efficiency. The next line on the diagram running from 1925 to 1930 shows the average efficiency of all the plants in the Chicago district. This diagram also shows the "heat-rate" of Crawford, Waukegan, State Line and Powerton stations. These stations now form the foundation of the Chicago system power supply. The other stations, Calumet, Fisk Street, Northwest and Quarry are now more or less reserve or standby stations.

For the first six months of 1929, the average heat rate of all the stations of the Chicago district was 18,050 B.t.u. per kw-hr., and for the last six months of 1929 it was 16,780 B.t.u. per kw-hr. For the first three months of 1930, however, this figure has dropped to 16,400 due to State Line and Powerton. This represents a low heat rate for a large system, but this average heat rate for the entire system depends upon the percentage of the total output that can be put on the newer and more efficient stations.

The most efficient station on the system as it stands today is Powerton, which has for the past six months shown an average station efficiency of 12,610 B.t.u. per kw-hr. of output, and has generated an average output of 55,341,450 kw-hr. per month. The State Line Station has not as yet shown quite so good efficiency. There has been some trouble with the high-pressure turbine and with some of the minor details. It is operating now on about 13,300 B.t.u. per kw-hr. and when certain adjustments are completed the station should about equal the efficiency of Powerton, given a similar load condition. But Powerton has the benefit of a much lower cost of coal so that, naturally, it is given a better night load.

If Powerton was supplied with a high grade coal with low ash and moisture, its efficiency would be just about 12,000 B.t.u., but it is impossible to do so well with the coals having a high percentage of ash, hydrogen and moisture.

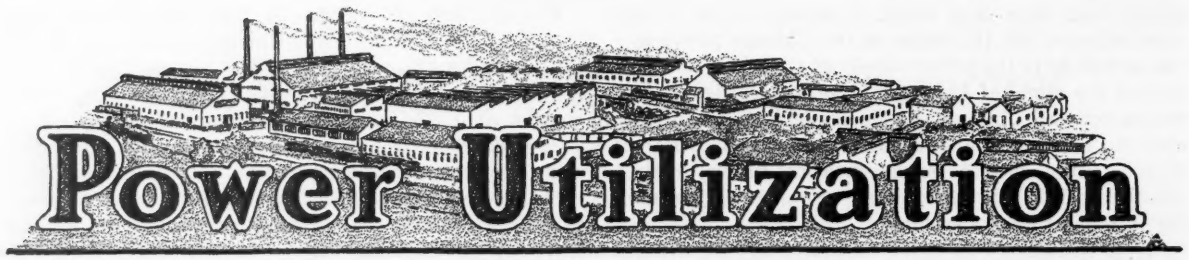
"I think I am safe in saying," said Mr. Monroe, "that the six months record of the Powerton Station has not been equaled by any station in the world, and its output per 1000 kw. of capacity installed is also a world record. The station meters and also the methods of weighing, sampling and testing the coal of all the stations have recently been calibrated and checked by impartial experts, and we feel sure the results are correct."

DURING 1929, the total number of electrified farms in the United States increased from 460,000 to 558,000, or by 21.5 per cent. This is the largest annual increase so far recorded.

At the end of 1923 there were only 166,140 farms receiving electric service, according to a survey made by the Rural Electric Service Committee of the National Electric Light Association. Since that time, the total number has been increasing at a rate which doubles every 3½ yr.

California leads in the number of farms supplied with service by the light and power companies with a total of 72,690 at the end of 1929, representing an electrification of 53 per cent. New York comes next with 53,060; Ohio third, with 38,045; Washington fourth, with 37,813; followed by Pennsylvania, Wisconsin and Michigan in the order named.

Montana heads the list for the greatest percentage increase during the past year. On December 31, 1928, this state had only 890 electrified farms which number increased during the year to 1844, or by 107.2 per cent. Arizona comes next with a percentage increase of 93.1 per cent; New Hampshire third with 79.1 per cent; Nebraska fourth with 61.5 per cent and South Carolina fifth with 46.3 per cent.



Power to Operate Conveyors

STORAGE AND RECLAIMING OF COAL DIFFER IN POWER NEEDED FOR INDUSTRIAL CONVEYORS. BY EDWARD J. TOURNIER

BOOKS, MAGAZINES and the daily press have been praising, or condemning, according to the state of the writers' digestion, what is becoming known as the Machine Age. Henry Ford prefers to call it the Power Age, and with reason, since machines would be useless if they did not either make or use power. And as industry saves or wastes power, everybody gains or loses something; in the aggregate, a great deal.

HANDLING COST NOT EASILY ASCERTAINED

Since materials-handling equipment and conveyors in particular have become prime factors in the industrial scheme, the selection of such apparatus is being made on the basis of cost per unit handled. In most instances, the allocation of this cost is not an easy matter because there is yet in general use no system of accounting which provides a set-up for all of the items of handling cost. For example, one plant making automobile frames by an entirely continuous, automatic system of handling can ascertain closely the cost per unit but a radio factory, where only part of the work is done on conveyors, cannot do so easily.

Aside from the cost of direct handling of parts, in either of the cases mentioned, the question of power for operating the conveyors is one which is easily lost sight of and eventually becomes one of those hidden costs we hear about. The selection of conveying equipment in manufacturing plants is seldom greatly affected by the power question because the savings over hand methods made possible by a conveyor using even an excess of power is so great that power is a minor consideration.

CONVEYOR OPERATION COST FOR POWER PLANT IS IMPORTANT

When we come to consider a plant whose function is to produce power, we face a different situation. In this case, every kilowatt put into the conveyor system must give an account of itself; no more power must be used than is necessary to do the work. The same care should be used here in selecting the handling equipment as is employed in the conservation of heat. We know, however, that often such is not the case; many times a coal conveyor is installed on the basis of initial cost. A brief analysis of the power requirements of power plant mechanical handling equipment may throw a little light on the subject.

Generally, coal must be stored in the boiler house bunker for daily use, with an outdoor supply as a reserve. The former will be, perhaps, 100 to 200 t., while the latter may be 10,000 t., or more. The outside storage area will, therefore, be several times the size of the bunker. It follows, then, that any conveying system used to bring the coal into the boiler house could be divided into two sections, one extending from the ground storage to the boiler house and the other extend-

FIG. 1. LOADED STRAND OF LINK-BELT PIVOTED-BUCKET CARRIER

FIG. 2. ROBBINS BELT TRIPPER DISCHARGING COAL INTO BUNKER

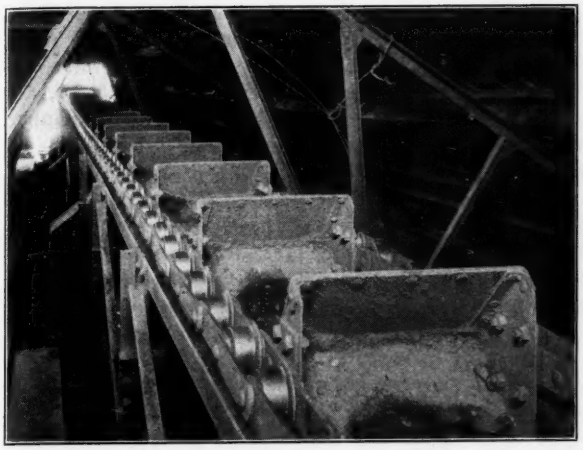


FIG. 3. FRICTIONAL RESISTANCE IN THESE JEFFREY GRAVITY BUCKET ELEVATORS IS REDUCED BY THE USE OF ROLLERS ON THE CHAIN

ing into the building. A comparison of the various types of machinery is then readily made, if we bear in mind that *so far as power is concerned, there will be no material differences among any types selected, for a comparatively short section within the building,* say up to 100 ft. A considerable difference exists, however, in the portion extending from the top of the bunker to the ground. In order to clarify this statement, it may be well to note, first, the types of equipment generally used, as follows: Belt conveyors, pivoted-bucket carriers, gravity bucket elevator-conveyors, and flight conveyors. In point of power economy, the conveyors are properly listed as cited above, which will be demonstrated. The explanation of the differences in power consumption is to be found by examination of the principles of design involved in the various kinds of conveyors. Briefly stated, they are as follows:

Classification of Conveyors

Power required to operate a conveyor is that necessary to overcome the frictional resistance and weight of the material handled and of the conveyor elements. In belt conveyors and pivoted-bucket carriers, the frictional resistance is modified by the use of rollers on which the weight is carried instead of being dragged, as

FIG. 4. IN FLIGHT CONVEYORS FRICTION IS CAUSED BY SLIDING OF MATERIAL ON TROUGH PLATES

FIG. 5. FLIGHT CONVEYOR RISING FROM THE TRACK HOPPER AT A STEEP ANGLE

is the case in scraper conveyors. In gravity bucket conveyors, the friction is caused partly by material sliding in a trough and partly by the weight of the chain and buckets carried on rollers. In flight conveyors of the scraper type without rollers, frictional resistance is due to the weights sliding on the trough plates. The fundamental difference, then, between roller-supported conveyors and sliding chains, lies in the difference between rolling friction and sliding friction. Consequently, the statement may be made that horizontal conveyors entirely supported on rollers will have 1/3 of the frictional resistance of drag or scraper conveyors.

Power Calculation for Conveyors

Comparison of two examples, one of a pivoted bucket carrier and the other a belt conveyor will show the relative power consumption of these two types. In making this comparison, it must be remembered that the two strands of chain on the bucket conveyor are much heavier than the corresponding parts of the belt conveyor. It will be assumed that the conveyors are each 100 ft. long, handling 75 t. of coal an hour. A pivoted bucket to handle this capacity will have buckets 24 by 24 in., and will have a chain speed of 60 ft. per min.

Power required is represented by:

$$\text{Hp.} = C \times L$$

in which,

C = A constant from Table I and

L = Length of conveyor in feet, center to center of shafts.

FIG. 6. TRAVELING BRIDGE FOR UNLOADING AND RECLAIMING COAL USED BY WATER SIDE PLANTS

In the case under consideration,

Hp. = 0.035 × 100 = 3.5, to which must be added 20 per cent for the losses in transmission, making a total of 4.2 hp.

TABLE I. CAPACITY AND HP. OF PIVOTED-BUCKET CARRIERS

Size of Bucket (Inches)	Tons per Hour	Constant, C.	Constant, D.
16 × 18	35	0.026	0.045
18 × 24	60	0.030	0.065
24 × 24	80	0.035	0.090
30 × 24	100	0.045	0.108
30 × 30	150	0.055	0.140
36 × 30	180	0.060	0.165

The constant, D, is used when the conveyor is used to elevate as well as to convey, as for example, when coal is transferred from a track hopper to an overhead bunker. In that case:

Hp. = (C × L) + (D × H)

L being the same as before and H = Height lifted, in feet.

In the case of a belt conveyor, a 20-in. belt running 250 ft. per min., will handle 75 t. per hr., of coal and the power required is represented by:

Hp. = T × E × L ÷ 1000

in which, T = Tons per hour, E = A constant from Table II, L = Length of conveyor, in feet.

Then, for a conveyor 100 ft. centers, handling 75 t. per hr.,

Hp. = 75 × 0.189 × 100 ÷ 1000 = 1.42 hp.

Adding 1.68 hp. for drive and belt tripper gives 3.1 hp. required at the countershaft.

TABLE II. POWER FACTORS FOR BELT CONVEYORS WITH PLAIN BEARING IDLERS

Width of belt (inches)	Maximum Speed in ft. per min.	T.p.h. at 100 F.p.m. Material 50 lb. cu. ft.	Constant E	Tripper hp.
12	300	12	0.177	0.50
16	300	20	0.172	0.75
20	350	32	0.189	1.25
24	400	50	0.181	1.75
30	450	75	0.161	2.50
36	500	110	0.150	3.25
42	550	300	0.147	4.25
48	600	400	0.138	5.00

If the conveyor is inclined:

Hp. = (T × E × L ÷ 1000) + (T × H ÷ 1000)

in which, T = Tons per hour, E = A constant from Table II, L = Length of conveyor, in feet, H = Height material is lifted, in feet.

Power for Conveying and Elevating

Another case might be considered with advantage, as the preceding one illustrated a condition met with usually inside of the boiler house, that is, it was a horizontal conveyor.

As an example, we may take the problem of bringing crushed coal from a pit below the track hopper, in which the loading point of the conveyor is approximately 12 ft. below grade, and the top of the bunker, 35 ft. above. Two types in most common use for this purpose are flight and belt conveyors. The latter can be operated safely on a maximum angle of 20 deg. to horizontal in handling soft coal; the former may be run up to 35 deg. On this basis, with a lift of 47 ft., the flight conveyor will be 160 ft. long, the run over the bunker being 75 ft. The belt conveyor will be 215 ft. long. If the capacity handled is 40 t. per hr., a 16-in. belt at 200 ft. per min. will do the work, while the flight will be 15 by 6 in., with a chain speed of 100 ft. per min. Under these conditions, the flight conveyor will require 6.5 hp. for operation and the belt conveyor, including the tripper, will use 4 hp., based on plain bearing idlers.

In the case just cited, the difference in power requirements is not so great as to militate against the use of the flight conveyor, particularly as the latter is less expensive initially. If, however, we consider the same lengths of conveyors and increase the capacity to 100 t. per hr., there is a considerable difference in power consumption.

A double strand, roller chain flight conveyor, with flights 20 by 10 in. at 100 ft. per min., will be required for the capacity given, and a 20-in. belt at 300 ft. per min. will handle the same capacity. The flight conveyor uses 16.2 hp., while the belt uses 10.5 hp. for the

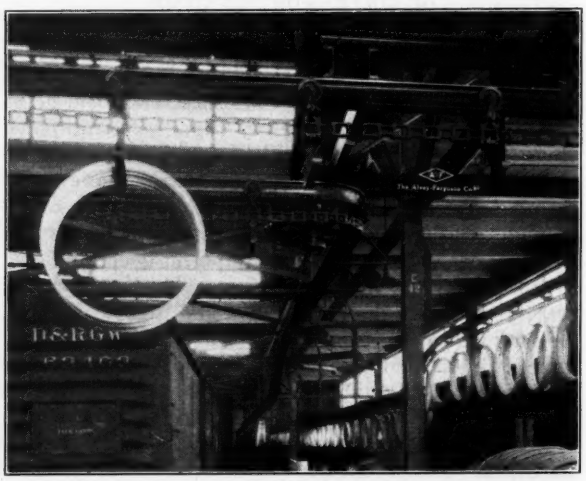


FIG. 7. MONORAIL CONVEYORS WITH TROLLEYS AND HOOKS FOR HANDLING TIRE RIMS

specified duty, under running conditions. The motors will be 20 hp. and 15 hp. respectively. In the event that anti-friction idlers are used on the belt conveyor, a 10-hp. motor would be sufficient.

The bare statement of these facts indicates that, considering the power question alone, the belt conveyor is the more economical equipment. The same is true, also, as to first cost when the length of the conveyor is over 150 ft. and if there is any considerable lift involved.

It should be noted at this point that, in an actual installation, a flight conveyor having an inclined section followed by a horizontal portion would not be made in a single, continuous length. Usually it is more convenient, from both the engineering and operating standpoints, to build the conveyor in two parts, with the inclined portion discharging into the horizontal part. Or a gravity-discharge elevator-conveyor could be used. In any case, however, the power requirements would not be less than for a flight conveyor. Tables III and IV will serve as a guide for comparisons.

So far, this discussion has dealt primarily with conveyors for transferring coal from the track hopper to the boiler house and with the distribution of fuel in

the bunkers. The storage and reclaiming of coal is a subject equally important.

Coal Storage and Reclaiming Systems

Formation of the fuel reserve is generally accomplished by one of two methods. If the plant is located at the water-side, vessels are unloaded either by coal-hoists or by traveling, unloading bridges. In either case, a system of conveyors on the land area back of the dock supplies the means of storage. Reclaiming can be done by the same bridge that is used for unloading, or if a hoisting tower is unloading, a locomotive crane can be used for reclaiming.

If the plant is served by a railroad, the most common method of storing and reclaiming, is with a drag-line scraper in conjunction with conveyors. It must suffice, here, merely to mention the unloading facilities in order that we may examine more closely the storage conveyors.

Modern power plant practice has determined the type of conveyor best suited to storage purposes. In the largest developments of industrial and central station power plants, belt conveyors are used almost exclusively. From the standpoint of power consumption, the capacity handled, and the length of the conveyor are

TABLE III. CAPACITY AND HP. OF SINGLE STRAND CONVEYORS, HANDLING COAL AT 100 FT. PER MIN.

Size of Flight (in inches)	Capacity t. per hr. Horiz.	Inclined 30 Deg.	Hp. per 100 ft. length*
10 × 4	30	23	2.5
12 × 5	45	35	4.5
15 × 6	65	50	6.0
18 × 6	80	60	7.0

*Includes power for inclined length.

TABLE IV. CAPACITY AND HP. OF DOUBLE STRAND FLIGHT CONVEYORS, WITH ROLLER CHAINS, HANDLING COAL AT 100 FT. PER MIN.

Size of Flight (in inches)	Capacity, t. per hr. Horiz.	Inclin. 30 Deg.	Hp.* Horiz.	Incl. 15 Deg.	30 Deg.
16 × 8	110	95	8	11	12
20 × 10	170	140	15	20	23
24 × 12	200	170	17	22	27
30 × 12	300	260	23	32	38
36 × 12	360	315	27	38	45

*Hp. is for each 100 ft. of length, with separate calculations for the inclined length.

the factors which settle the amount of power used. This comes about in two ways. First, the length of the conveyor will determine whether plain or roller bearing idlers are to be used. Second, if anti-friction idlers are used, the savings in power and belt thickness will pay for the difference in price between plain and anti-friction bearings in the idlers. Two examples will amplify this statement.

If we consider a 24-inch. belt conveyor, 200 ft. long, handling 125 t. of coal an hour at 250 ft. per min., the running horsepower is 9.4., when plain bearing idlers are used while, with anti-friction idlers, the conveyor requires 7.9 hp. In this case, therefore, the savings would be only those due to the difference in power; they would not be enough to warrant the investment in anti-friction idlers.

Let us consider next, a conveyor 36 in. wide, 1200 ft. long, handling 350 t. per hr. of coal, at 300 ft. per min. If plain idlers are used, it will require 60 hp. to operate the conveyor; with anti-friction idlers, the belt will use 32 running horsepower. This not only results in a great saving of power but also reduces the thickness of the belt, the size of pulleys and of the power transmission elements. The net money savings from these sources, on a conveyor 1200 ft. long, amount to over $1700, which is more than enough to pay for the low-power idlers. The power saving is therefore so much clear gain.

Industrial Purpose Conveyors

Industrial conveyors is the name commonly used to designate equipment for progressive-assembly manufacturing operations and in the various continuous processes of industry.

As is well known, the application of a continuous conveyor for assembling complete units of equipment, from parts brought to the assembly line by auxiliary conveyors, had its origin in the automobile factory. This factory conveyor system has since been used as the basis

FIG. 8. WOOD APRON CONVEYOR FOR ASSEMBLING STEEL FILING CABINETS

for the installation of similar apparatus in practically every industry whose market requires quantity production. It is literally true that everything from soup to nuts is being handled on conveyors.

Factory conveyors are divided into two general types: chain conveyors and belt conveyors. The former are classified further as monorail chain conveyors, continuous wood aprons and steel apron conveyors.

Monorail conveyors usually consist of a single strand of chain, either of steel or malleable iron, fitted with two-wheel trolleys at intervals, so that the wheels travel on an I-beam track. Attachments of any required design are suspended below the trolleys in such a manner that loads placed on the hooks will produce only tensile stresses in the chain. Both wood apron and steel apron conveyors are made up of two parallel strands of chain with slats of steel or wood, as the case may be, fastened to each strand of chain.

Belt conveyors such as those used in manufacturing and assembly operations are flat, instead of being troughed, as in bulk handling conveyors.

It has already been intimated that the power required for operating industrial process conveyors is not generally an important consideration and this is borne out by the facts. As an example, a monorail conveyor 1000 ft. long, handling rims for automobile tires at the rate of 600 per hr., requires less than 5 hp. for operation. The power consumption of the other types of industrial conveyors is in the same proportion, as it seldom happens that more than a 3-hp. motor is needed. Table V indicates the power economy of industrial conveyors.

Light service conveyors are usually intended for handling packages, boxes and small parts employed in the assembly of mechanical or other equipment. Heavy

TABLE V. CAPACITY AND HP. OF WOOD APRON CONVEYORS HANDLING PACKAGES AT CHAIN SPEED 60 FT. PER MINUTE

Light Service					Heavy Service				
Width of Apron (in.)	Load on Conv. per ft. (lb.)	Hp. for length of 50 ft.	Hp. for length of 100 ft.	Hp. for length of 150 ft.	Width (in.)	Load per ft. (lb.)	Hp. for length of 50 ft.	Hp. for length of 100 ft.	Hp. for length of 150 ft.
18	15	0.50	1.1	1.5	24	50	1.4	3.0	4.0
24	25	0.65	1.3	2.0	30	65	1.7	3.3	5.0
30	30	0.75	1.5	2.2	36	75	2.0	4.0	6.0
36	35	0.85	1.75	2.5	48	100	2.5	5.0	7.5

service conveyors are generally used for handling machinery parts such as motor blocks, metal furniture, large boxes and the like.

Flat belt conveyors are used almost entirely when the loads to be transferred are quite light, as in the assembly of electrical instruments, radio parts and electric irons. In all of the conveyors, however, it will be noted that the power requirements are small compared with those of coal or other bulk handling conveyors. The accompanying table gives the capacity and power requirement of typical flat belts.

TABLE VI. POWER FOR FLAT BELT CONVEYORS

Width of Belt (inches)	Load per Foot (lb.)	Hp. per 100 ft.
14	5	0.30
20	10	0.55
24	10	1.00
30	10	1.25
36	15	1.40

It is apparent that the power requirements for industrial conveyors are such that selection of any given type will be governed by the service to be performed rather than by a power basis. In the case of power plant conveyors, the situation is somewhat different and, as every plant engineer knows, many factors are to be considered in the selection of such equipment. If it were necessary to state briefly the basis of choice, it would be the following:

For short coal conveyors of small capacity, use single strand flight conveyors; they cost less to buy.

For long, heavily loaded coal conveyors, use belts; they cost less to run.

Air Compressors and Receivers

SELECTION, INSTALLATION, CARE AND OPERATION. BY H. L. KAUFFMAN

MANUFACTURERS usually rate the sizes of air compressors in terms of piston displacement in cubic feet per minute. Do not confuse this rating with the true capacity, which is the actual amount of air compressed and delivered, expressed in cubic feet per minute at intake temperature and pressure. Actual capacity is affected by such factors as the discharge pressure, the number of stages of compression and the altitude at which the compressor is to work.

When an uninterrupted supply of air is essential or for any condition where large capacities are required, the compressor plant should be divided into two or more separate units, so that air service will not be completely disrupted, should one unit be down for repairs.

Conditions under which single-stage, two-stage or multi-stage compression are advisable, are given as follows in the "Trade Standards" adopted by the Compressed Air Society:

"For gage pressures up to 60 lb. per sq. in., single-stage compression should be employed. Whether to use single-stage or two-stage compression for pressures between 60 and 100 lb. per sq. in. will depend largely on the capacity required, the cost of the driving power, the altitude at which the machine is to work and whether or not it is to be a permanent installation. No doubt multi-stage compression is more economical for gage pressures over 60 lb. per sq. in. though single-stage compressors of less than 350 cu. ft. per min. displacement are to be recommended as satisfactory for pressures as high as 110 lb. per sq. in.

"It is generally recognized that multi-stage compression should be used in permanent installations for pressures of 100 lb. or more, with displacements of 300 cu. ft. per min. or more. Discharge gage pressures of 80 to 125 lb. per sq.in. are considered standard for two-stage compression. There can be no exact dividing line in the range of capacities and pressures to determine where single-stage compression should stop and two-stage compression should begin: there must necessarily be some overlapping due to different conditions."

INSTALLING THE COMPRESSOR AND AIR RECEIVER

Air compressors need inspection, cleaning and repairing from time to time, hence locate your compressor so as to provide plenty of light and space for performing these operations with ease.

Although air filters are now in common use for minimizing the amount of dust that is drawn in at the air intake, it continues to be good practice to locate a compressor in a room or building where dust in the air is the least and to extend the air intake to a point outdoors where the cleanest and coldest air possible can be obtained. Naturally, you will want a solid and firm foundation for the compressor but don't get the idea that all foundations can necessarily be made the same. Foundation design will vary with local soil conditions and the type of unit being installed.

Getting colder air from outdoors results in increased compressor capacity and efficiency. Table I from the Compressed Air Society's Trade Standards shows specific evidence that an actual gain in delivery of 1 per cent is obtained for every 5 deg. temperature reduction of the intake air. Intake piping should be the full diameter of the inlet opening on the air cylinder, the intake opening being hooded to prevent the entrance of rain and screened to keep out dust and other foreign matter. Personally, the writer believes that air filters will save money by decreasing operating and maintenance costs, in 9 cases out of 10 and, without prejudice, advises that air-filter manufacturers be consulted as to their recommendations for the proper size for a given compressor.

Intake conduit may be of standard steel pipe, sheet metal pipe, vitrified sewer pipe, brick or concrete. For

TABLE I. INTAKE AIR TEMPERATURE AND COMPRESSOR CAPACITY

Initial Temperatures		Relative Capacities	Initial Temperatures		Relative Capacities
Degrees Fahr.	Degrees Absolute		Degrees Fahr.	Degrees Absolute	
—20	440	1.18	70	530	.980
—10	450	1.155	80	540	.961
0	460	1.13	90	550	.944
10	470	1.104	100	560	.928
20	480	1.083	110	570	.912
30	490	1.061	120	580	.896
32	492	1.058	130	590	.880
40	500	1.040	140	600	.866
50	510	1.020	150	610	.852
60	520	1.00	160	620	.838

above-ground installations, standard steel or sheet metal pipe is preferable; either glazed, vitrified sewer pipe or concrete, lined with glazed material, makes a convenient duct for underground air intakes. The objection to the use of concrete, unpainted or without a smooth lining of some sort, is the difficulty in getting a surface so smooth and hard that no particles will crumble from the sides and be drawn into the compressor by the rush of air. Avoid sharp bends. Make all joints water tight by the use of suitable cement.

Air discharge pipe should be the full size of the discharge opening on the air cylinder and should lead directly either to an aftercooler or, if no aftercooler is used, then directly to the air receiver. Keep the piping away from all flammable materials. Avoid sharp bends and low points where moisture, oil or other impurities discharged by the compressor might accumulate. Make all joints air-tight with red lead or other suitable sealing compound for air leaks are expensive.

Never, except as will be explained, place a globe or gate valve on the line between the compressor and the aftercooler or receiver. When an unusual condition makes it advisable to have a valve in this line, insert a tee ahead of the valve and screw into this tee a short length of pipe with a safety valve and a globe valve in it, Fig. 1. Such an arrangement will prevent sudden and dangerous building up of pressure should the shut-off valve be closed. When the safety valve blows, it gives warning to the operator of existing conditions. All piping

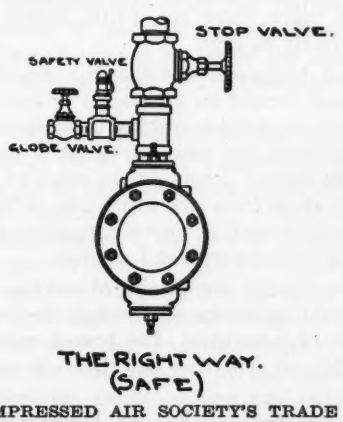


FIG. 1. COMPRESSED AIR SOCIETY'S TRADE STANDARD ARRANGEMENT FOR VALVE IN COMPRESSOR DISCHARGE

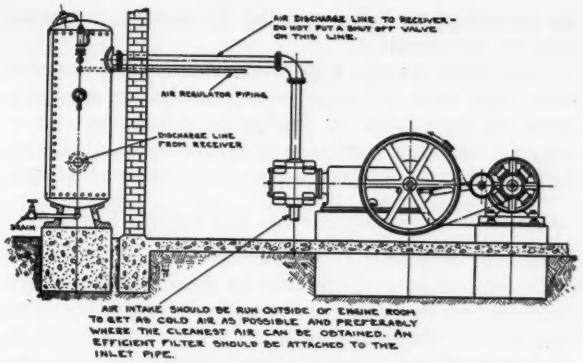

AIR DISCHARGE LINE TO RECEIVER - DO NOT PUT A SHUT OFF VALVE ON THIS LINE.
AIR REGULATOR PIPING
DISCHARGE LINE FROM RECEIVER
AIR INTAKE SHOULD BE RUN OUTSIDE OF ENGINE ROOM TO GET AS COLD AIR AS POSSIBLE AND PREFERABLY WHERE THE CLEANEST AIR CAN BE OBTAINED. AN EFFICIENT FILTER SHOULD BE ATTACHED TO THE INLET PIPE.

FIG. 2. GENERAL ARRANGEMENT OF COMPRESSOR AND RECEIVER, FROM COMPRESSED AIR SOCIETY'S TRADE STANDARDS

should be connected with flanged or screwed unions close to the cylinder, so that one can remove the cylinder, whenever necessary, without disturbing the piping.

Air Receivers

Air receivers should always be placed outdoors, if at all possible to do so. The receiver should be located, however, at no great distance from the compressor, so that piping between compressor and receiver will be as short as possible. The purpose of an air receiver is to to equalize the discharge pulsations from the compressor so as to deliver a steady flow of air to the service line. The size of the receiver will depend upon the demand, but it is better to get it too large than to get a small one and find later that its capacity is inadequate. Table II, by the Chicago Pneumatic Tool Co., gives some pertinent information concerning the relationship that should exist between the size of an air receiver and compressor capacity.

Never use second-hand air receivers, or old boilers that you contemplate using as receivers, without first having them thoroughly tested and approved by an authorized state or insurance company inspector. Otherwise a serious accident may result.

No air receiver should be set on the ground, for the dampness of the soil will cause excessive rusting and corrosion around the bottom; instead, place it on blocks or on a small foundation. Connect the discharge from the compressor or aftercooler to the receiver at a point near the top. See that a drain cock is located at a low point in the receiver for drawing off accumulated oil, water or other impurities. Check the pressure gage on the receiver against a standard gage and correct when necessary. See that the safety valve is of sufficient area to prevent excessive pressure rise in the receiver, when

TABLE II. AIR RECEIVERS FOR PRESSURES UP TO 125 LB. A. S. M. E. CODE

Compressor Capacity for which Receiver is Suited Based on Actual Air Delivered at Working Pressure Shown			Diameter, Inches	Length, Feet	Volume, Cu. Ft.	Approx Weight, Pounds	Thickness of Shell, Inches	Thickness of Heads, Inches		Diameter of Inlet and Discharge Openings, Inches	Safety Valves, No. Used; Diameter, Inches		Size of Drain Valves, Inches	Type of Opening for Cleaning
80 Lbs.	100 Lbs	125 Lbs.						Top	Bottom		No.	Diam.		
50	60	70	14	4	4	220	3/16	7/32	3/16	2½	1	¾	¾	2 Hand Holes Near Heads
80	95	110	18	6	11	410	3/16	17/64	3/16	3	1	1	¾	
165	185	220	24	6	19	725	1/4	3/8	1/4	3	1	1½	1	One Manhole In Top Head
260	305	355	30	7	35	960	1/4	7/16	17/64	4	1	2	1	
390	450	530	36	8	57	1475	19/64	7/16	5/16	6	1	2½	1	
540	640	740	42	10	96	2400	23/64	1/2	23/64	6	1	3	1	
1085	1275	1495	48	12	152	3900	13/32	9/16	13/32	8	2	3	1¼	
1625	1910	2240	54	14	224	5600	3/8	9/16	7/16	10	3	3	1¼	
1870	2200	2500	60	14	254	6075	13/32	1/2	1/2	12	3	3	1¼	One Manhole In Shell
2800	3300	3900	66	18	396	8375	7/16	9/16	9/16	12	3	3	1¼	

the amount of air being supplied the receiver is greater than the consumption.

As is often the case with other machinery, it has been found that most air compressor troubles are traceable either to inadequate or ineffective lubrication or to neglect in making regular and careful inspection, correcting the little troubles before they become big ones.

Care and Operation of Air Compressor Systems

Regular draining of the air receiver is especially important. It is good practice to open the drain cock every day, either before or just after starting the compressor. The amount of oil entrained with the water in the bottom of the receiver often explains why oil consumption seems high. Cleaning of the receiver at regular intervals is also advisable for, especially when no aftercooler is used, carbon deposits are likely to be formed on the walls and dangerous pressures will be developed should this become ignited. Soap-sudsy water is commonly used for cleaning the compressor proper, but a lye (caustic soda) solution can be used for cleaning the receiver and the discharge pipe between the compressor and the receiver.

To do this, dissolve 1 lb. of high-grade lye in two gal. of water. While the compressor is running, this mixture is forced into the discharge pipe at a point where it is impossible for it to run back into the compressor. Preparations for introducing the mixture must be made, however, when the compressor is not running, by connecting both the top and bottom of the lye-solution container (which may be a 6-in. pipe capped at both ends, but with a ½-in. pipe attached thereto) to the discharge pipe; or, if more convenient, the small pipe leading from the top of the container may be tapped into the receiver. It is necessary to have such a connection from the container leading either to the discharge line or to the receiver in order to balance the pressures. A small pet cock should be placed in the ½-in. pipe at the bottom of the container, in order to regulate the flow of the mixture into the system. By forcing this mixture into the discharge pipe at the rate of about 75 drops a minute while the compressor is running, all the accumulation of oil and carbon will be removed from the inner surfaces of both the discharge pipe and the receiver. It can be removed from the receiver by opening the blow off valve.

Never use kerosene or light-bodied lubricating oils to remove the carbon deposit that forms in the cylinders and around the discharge valves of the compressor. Such products have a low flash point, hence their use is unsafe. Instead, use warm soap-sudsy water which can be pumped into the cylinder by means of either a hand pump or the regular force-feed lubricator adjusted for about ten times normal speed. It is good practice to use sudsy water for a few hours about once a week in place of oil. After using soap suds, open the drain cocks of the receiver and of the intercooler or aftercooler, if compressor design is such that either has to be used, to draw off any accumulated liquid. Then use oil in the system for about a half hour before shutting down the machine, in order to prevent rusting of the cylinders and their fittings.

Stepladders, gratings and stairways should always be kept in perfect repair.

Water Supply Air Bound

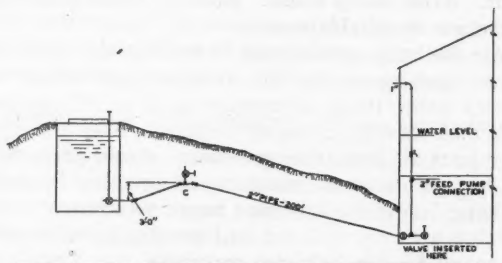
Visiting a friend's plant, both friend and plant were found in trouble because the water supply for the boiler had failed.

Looking over the layout, it appeared that a 2-in. pipe entered the basement near the floor, then turned vertically upward to a point 10 ft. above the first story floor where it ended in a reducing elbow and a 1-in. pipe extending outdoors through the side wall. A draw-off outlet was provided near the basement floor, a faucet above the first floor and connection for the boiler feed pump suction just below the basement ceiling.

Following outside the mill, the 2-in. pipe ran some 4 ft. underground for 200 ft. up a hillside to the crest, then dipped down 3 ft. to the bottom of a well, which was fed by springs. Inside the well, the end of the pipe was fitted with a valve whose stem extended to the top of the well.

Normally, the water level in the well was a foot or more above the highest point in the pipe at the crest of the hill, and water rose in the mill supply pipe so that it could be drawn from the faucet.

When I arrived, water would not rise to the boiler pump connection, though it would flow slowly from the basement outlet.



ELEVATION OF PIPING THAT GAVE TROUBLE

Requisitioning a millwright's level and a couple of poles, we leveled the course of the pipe line as accurately as possible. Water in the well was found to be a few inches above the crest of the pipe line, so water could flow into the pipe.

We closed the inlet valve to the line, cut the line at the crest, made in a tee with outlet looking up and screwed in a branch with valve on the end. This branch was filled with water and its valve closed. Then opening the inlet valve, water rose to the faucet in the mill and flowed freely as ever.

What had happened was that air, separating from the water, had formed an air pocket in the crest of the pipe, acting as a vacuum cushion between the two ends and thus reducing the head on the mill supply. Had the pipe been buried deeper at the crest of the hill, to give a steady slope from well to mill, no difficulty would have been experienced, as any air separating out would have bubbled into the well and escaped.

After the change, air would, of course, accumulate again but could be drawn off through the branch valve. As a matter of precaution, the branch valve was left cracked a bit all the time so that air escaped continuously.

Indianapolis, Ind. James F. Hobart.

Oxy-Acetylene Welded Piping Specifications

DUE TO INCREASING use of welded construction in piping systems for all classes of service, a set of specifications has been prepared by the Linde Air Products Co. to cover correct construction and to be added to the general specifications for a piping installation. The provisions are as follows:

1. General specifications of conditions, requirements and drawings are in no way affected, the welding specifications applying only to substitution of oxy-acetylene welding for other types of joints.

2. All piping is to have welded joints unless otherwise directed by architect or engineer.

3. All joints are to be welded by the oxy-acetylene process.

4. Pipe shall be of commercial grade, good weldable quality, free from defects, of size and thickness required.

5. For steel pipe welds, high-test welding rod shall be equal to Oxweld No. 1 or its equivalent. For bronze and brass pipe welds, Oxweld No. 10 welding rod and Brazo flux or their equivalent shall be used.

6. All welding to be by competent welders and in first-class workmanlike manner.

7. Proof of competence of each welder to be furnished or a typical weld to be made in the presence of the engineer or his representative, joining two 9-in. sections of the largest pipe to be used, (6 in. diam. is minimum for this test) and joint to be tested by sledging 1-in. strip cut longitudinal of the pipe, gripped in vise jaws at the weld and hammer until fracture occurs. Fracture must show complete fusion to the bottom of the vee and to the side, sound weld metal, no cold shuts or other defects. Tensile coupons cut from the weld shall show minimum tensile strength of 45,000 per sq. in.

8. All line welds to be of single vee butt type, pipe ends to be mill or machine beveled to 45 deg. to within $\frac{1}{16}$ in. of inside wall. For thickness of $\frac{3}{16}$ in. or less, may melt down into and build up over abutting ends, instead of beveling.

9. Abutting ends of joints are to be separated to permit complete fusion to the bottom, tacked at two or more points to maintain alinement, then welded. Wherever possible, welding shall be continuous around the pipe.

10. All weld metal to be sound, thoroughly fused into ends of pipe and bottom of vee and built up to give reinforcement $\frac{1}{4}$ the pipe wall thickness, increasing from surface of pipe to center of the weld. Minimum width of the weld shall be $2\frac{1}{2}$ times the pipe wall thickness.

11. Fillet welds for flanges or fittings shall be fused into pipe and plate for at least $1\frac{1}{2}$ times pipe wall thickness and built up to have minimum depth of weld $1\frac{1}{4}$ times pipe wall thickness.

12. Standard flanges, if of cast or forged steel, to be welded to pipe at back of flange or pipe to be inserted or screwed into flange within $\frac{3}{8}$ in. of face and welded front and back. Special designed long hub flanges with short stub may be butt welded to pipe.

13. Unless otherwise directed by the engineer, tees, branches, connections, bends, swages and other fittings shall be fabricated by welding or designed with carefully matched intersections and properly prepared, to be welded into the pipe system.

14. Anchors to be of welded shapes, welded to the pipe, of design as required by the engineer.

15. Fittings and odd lengths of pipe may be cut and prepared by oxy-acetylene blow pipe but cut surfaces to be welded shall be regular and cleaned of all oxide by grinding, filing or other suitable method.

16. All-welded piping for working pressure over 15 lb. shall have hydrostatic test at $1\frac{1}{2}$ times working pressure, all-welded joints being hammered while under that pressure with a 3-lb. hammer so as to jar the pipe and joint but not to injure the pipe. No welds to show any leaks or defects under this test.

Pipe for working pressure 15 lb. or less to be tested for tightness by air, steam or other medium and show no leaks or defects.

Double Belts from a Motor

BAD ARRANGEMENT of pulleys and belts is as shown in Fig. 1. The large pulley is the standard pulley on an electric motor, which is underloaded. Somebody sees

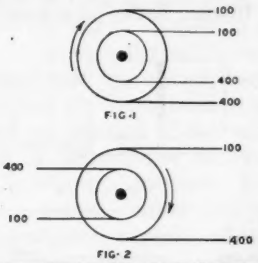


FIG. 1. TWO BELTS IN SAME DIRECTION ARE BAD
FIG. 2. OPPOSED BELTS RESULT IN BALANCED PULL

an opportunity to increase the load, so the smaller pulley is added. That is, two pulleys are placed side by side on the same overhanging shaft, both belts pulling against the bearing in the same direction, with a total pull as indicated by the figures of 1000 lb.

This is poor engineering because motor bearings are designed for a definite load and all bearings have their limitations. If the two belts leave the pulleys in the same direction, the chances are that the bearing and shaft will be unable to withstand the combined pull and bending moments. The outside pulley, being farther away, causes the bending stress to be greater in the bearing than that due to an equal pull on the inner pulley.

By arranging the drives so that the belts will leave in opposite directions, as shown in Fig. 2, the bending stress will be less than would be the case with a single pulley, fully loaded. Here we have 500 lb. acting in one directions, exactly balanced by 500 lb. acting the other way. True, the belt at the left, Fig. 2, has a top pull but that is better than ruining the motor for the sake of two under-pull belts.

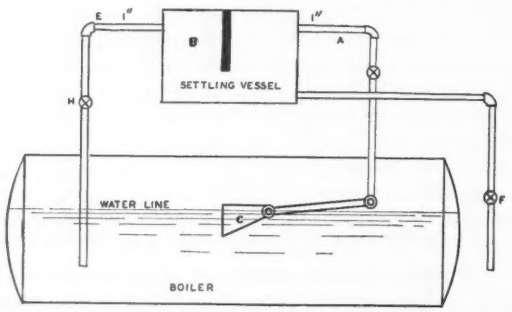
Another point to bear in mind is this: Overhung pulleys on electric motors should always be placed as close to the bearing as possible. If you must run belts as shown in Fig. 1, or if you must place a pulley at a considerable distance from the motor bearing, use an additional outboard bearings. The extra bearing will soon pay for itself.

Newark, N. J. W. F. SCHAPHORST.

Automatic Boiler Skimmer

FULLY OPENING a boiler blowoff cock quickly as suggested on page 247 of the February 15 issue is contrary to good prevailing practice. Slow action avoids shock and strain.

To install the surface blowoff pipe connection in the side of a return tubular boiler as suggested, some of the



CONDENSATION IN PIPE EFFECTS CIRCULATION IN AUTOMATIC BOILER SKIMMER

brickwork would have to be removed; connection of the pipe at the top of the boiler can be made without disturbing the brickwork.

Automatic skimmers that are on the market are far superior to the hand-operated type. One design consists of a piece of 12-in. iron pipe about 5 ft. long, flanged at the ends and supported on a stand resting on the floor in any convenient location.

In one skimmer of this type, outer pipe, A, shown in this illustration, should be long enough so that condensation will lower the pressure slightly in this pipe and cause the water to be drawn up in the pipe. The vessel, B, which has an internal diaphragm, is located above the boiler and connected as shown to the strainer funnel, C, which floats on the water and draws the water and floating substances from the surface. The water passes slowly through vessel, B, depositing sediment and passing back to the boiler through pipe, E. The velocity of flow can be regulated by valve, H. Sediment is blown out at intervals through valve, F.

Due to reduced pressure in pipe, A, the water drawn off at C is partially evaporated during its ascent. When the water and vapor thus formed enter the vessel, B, part of the vapor is condensed, due to heat radiation from the sides of the vessel so that pipe, A, contains a greater amount of steam than, E, causing the column of water in the latter to be the heavier and providing circulation.

Toronto, Canada. JAMES E. NOBLE.

Corliss Valve Setting Without Indicator

CORLISS VALVE SETTING, by J. F. Staley, published on page 469 of the Apr. 15 issue, prompts me to offer a few suggestions relative to this most fascinating branch of steam engineering. It is not my desire to criticize the method outlined by Mr. Staley, but rather to offer a few suggestions which, to my mind, may bring about better results or perhaps a better method of obtaining good results.

In setting Corliss engine valves, there are certain adjustments which must be made first and unless these are correctly made, the final valve adjusting will be to some extent incorrect, depending upon the amount of error which exists in the adjustments which are, so to speak, fundamental.

It is not necessary to place the engine on dead center, nor is it necessary to have the engine turned by hand from one dead center to the other at the commencement of Corliss valve setting operations. It is first necessary to back off the set-screws holding the eccentric to the shaft so that the eccentric may be rotated completely around the shaft by means of a suitable handbar which can be inserted in the side of the eccentric or by any suitable wrench or lever which may fit into the particular design of the eccentric. Rotate the eccentric on the shaft until the rocker-arm midway between the crank shaft and the wristplate is at an exact vertical position, as checked with a plumb-bob. If this position of the rocker-arm has not been marked on the hub, it should be marked for future reference by means of a sharp cold-chisel.

While the rocker-arm is in this plumb position, the wristplate should be checked and if it is not likewise in a plumb position, the length of the reach-rod from the rocker-arm to the wristplate should be adjusted in length so as to bring the wristplate into an exact plumb position, thus bringing the center line vertical through the wristplate parallel with the center line vertical through the rocker-arm. The reach-rod should be locked securely when this correct length has been obtained.

Next, the eccentric should be rotated slowly around the shaft so as to find out whether or not the rocker-arm oscillates an equal distance each side of its vertical or

central position. If the rocker-arm does not oscillate exactly equal distances each side of the center, the length of the eccentric rod must be changed so as to bring about this condition. When this adjustment has been properly made, the length of the eccentric rod must be secured by setting up firmly on the locking nuts, according to the design of the eccentric and eccentric rod.

We next must adjust the length of the dashpot rods so that our steam valves have the proper amount of lap. After this adjustment has been properly made with the attendant slowly rotating the eccentric on the shaft, we are able to lengthen or shorten the steam valve reach rods so that the valve latch will just hook on to the valve arm at each end. We can now place the engine crankpin on exact dead center, preferably the head-end dead center, and with the crankpin in this exact location, rotate the eccentric on the shaft in the direction in which the engine is to run until the steam valve on the head end has been opened the amount necessary for satisfactory lead, in which position one of the set-screws on the eccentric should be set down, holding the eccentric in that position.

The engine should now be turned by hand until the eccentric has reached its extreme travel in the direction which further opens the head-end steam valve, at which point and with the governor resting on the bottom, that is to say on the safety-stop pin, the trip cam should be adjusted so as just to unlatch the valve at the point where the valve has reached its maximum travel in the opening direction.

By rotating the engine by hand until the crank-end dead center is reached, the eccentric will have traveled on the return stroke far enough to have brought the crank-end steam valve into the same position of lead that was the condition for the head-end steam valve when the crankpin was on the head-end dead center and by continuing the rotation of crank shaft until the valve motion has again traveled to its limit of motion in the direction opening the crank-end steam valve, the governor trip cam for this end of the cylinder should be so adjusted as just to unlatch the valve arm when in its extreme position.

The exhaust valves can be set by placing the engine piston within a certain distance from each extreme dead center such as is in the opinion of the operator a satisfactory location for the exhaust valve closing to occur and by turning the engine in the direction in which it is to run until the piston arrives at that exact location for each end of the cylinder, each exhaust valve in turn can be brought with its closing edges line on line by properly adjusting the length of the exhaust valve reach-rods.

From the foregoing description of Corliss valve setting, it will be noted that the work is done by exact measurements and that the use of the steam engine indicator is not dealt with at all. It will also be noted that the governor trip cams are adjusted so as to unlatch the steam valve arm at the instant the steam valve has reached its extreme of travel in the opening direction, thus preventing the valve latch from holding on to the steam valve arm and carrying the valve arm back on its reverse motion, thus bringing about the latest point of cutoff at approximately three-fourths of the piston travel instead of at some point between one-third and one-half of the piston travel.

Here is a point, dealing with trip cam adjustment or setting that I believe many Corliss engine operators have not thought of seriously, that is, that the Corliss engine valve gear has been designed to control the speed of an engine so as to meet the variations of load and steam pressure by varying the point of cutoff within the range provided for the particular type of valve gear in each case. It is obvious, therefore, that if the trip cam does not unlatch the valve arm while the valve arm is traveling in the direction which opens the valve and if, at the very latest point in this direction of travel, the valve arm is not unlatched, then the valve arm cannot be unlatched at all during that particular stroke, but the valve is returned to this closed position, not rapidly by the action of the dashpot as it should be, but comparatively slowly because of being held in the valve latch and is, therefore, returned to its closed position at whatever speed the valve motion is making.

We have to consider, therefore, that the governor has full control of the point of cutoff and can vary it any amount necessary so long as that point of cutoff occurs while the valve is moving in its opening direction; but if, by what I see fit to term "misadjustment," these trip cams are adjusted just far enough back from the correct position so that the valve latch is not unlatched at the extreme opening position of the valve arm, then no cutoff occurs until the valve is returned by the valve latch and the horsepower developed by the engine instantly changes to almost double what is intended to be the maximum horsepower capacity of the cylinder.

This misadjustment of single eccentric Corliss valve gear trip cams is one I have frequently observed. It is done, seemingly, so that an engine will pick up its starting load easily. There is no particular objection to this setting, which permits the valve latches to hold on, as it is called, when starting the engine, provided the engine's normal operating load is less than requires the maximum or the latest point of cutoff but if the engine is fairly well loaded so that a drop in steam pressure or the least additional load, will bring the governor into its lowest position so that the valve latches are not tripped at the latest possible point of cutoff, then they hold on and the engine immediately changes in horsepower capacity from what was intended to be its maximum to approximately twice that capacity and this sudden change in power development, which is beyond the control of the governor, causes the engine to pick up speed and in a few rotations, sufficient speed is gained to cause the governor to float up high enough again to bring the trip cams into service.

When this happens, the engine tends to slow down to normal with the result that the governor falls again below the point of lowest cutoff when the engine starts in to pick up speed again and this condition continues until the load is reduced or the boiler pressure increased until the governors can float steadily at a point within the maximum range of cutoff so as the engine can carry its load at the proper speed regularly. This misadjustment of the trip cams is one which makes engines particularly hard to keep in condition because of the instantaneous change of torque produced on the shaft and the extreme stresses which are developed suddenly in the engine and its bearings.

To my mind, the adjustment is wrong. When a single eccentric Corliss valve gear engine becomes loaded to a point where it seems necessary to help out the situation by setting these trip cams back, there must be some other method which can be employed. The economy in steam consumption is lost by this misadjustment, fuel consumption per horsepower is greatly increased, the mechanical condition of the engine is certainly stressed and from every angle of consideration, something should be done to correct the condition along correct engineering lines.

If the condition results from over-load and it is likely to continue, it would be much better to bring the matter to the attention of the management, taking the necessary time to explain the truth of the condition and if nothing can be done, the valve gear could be changed and a double eccentric valve gear fitted on. Perhaps the allowable working pressure of the boiler could be increased so as to offset the overloaded condition by an increase in the boiler pressure available. Perhaps there may be, somewhere in the plant, exhaust steam heating equipment which, under the existing conditions, may be operating at a higher pressure than necessary. This high back pressure might perhaps be reduced by certain changes in the exhause piping system. These, however, are all conditions that can be studied out very satisfactorily by the man in charge of the particular plant. I am merely expressing some of the angles that may lead to the overloaded condition of the engine.

It is bad practice therefore, so to adjust the trip cams of any Corliss engine of the releasing gear type that it is possible for the valve latches to hang on. The correct method is so to set these trip cams that when the engine is being started and the governor is resting on the safety-pin or whatever form of safety device may be used, which means that the governor is in the position so as to bring about the maximum range of cutoff or, in other words, the latest point of cutoff for that particular type of valve gear, the same valve arm should be unlatched by the trip cam when the steam valve arm has reached its maximum point of travel in the direction which opens the steam valve.

Hartford, Conn. HARRY W. BENTON.

Limit Three-Phase Unbalanced Loads

UNEQUAL LINE currents in three-phase generators have a demagnetizing effect on the field and may result in burned-out field windings. When the currents in the three phases of a generator are not equal, the armature reaction or demagnetization of the field pulsates with a frequency equal to twice the frequency of the machine. This pulsation of flux induces an alternating current in the field iron and heats the magnetic structure. The extent of this heating depends on the amount of unbalance between the phases. If the out-of-balance current becomes too great, the heat may be sufficient to damage the insulation of the winding.

Water wheel generators should not be operated with a difference in current between maximum and minimum phase of more than 66 per cent of the rated full-load current. This figure should not exceed 30 per cent for turbine generators with forged field pieces and the difference should not exceed 15 per cent for turbine generators with laminated poles. The maximum out-of-balance current for turbine generators having solid rotors should not exceed 15 per cent if the end rings which hold the rotor windings in position are not insulated; however, the general practice is to insulate these end rings in most of the modern turbine generators.

Hobart, Ind. HARRY J. ACHEE.

Bracing Makes Cracked Cylinder Function

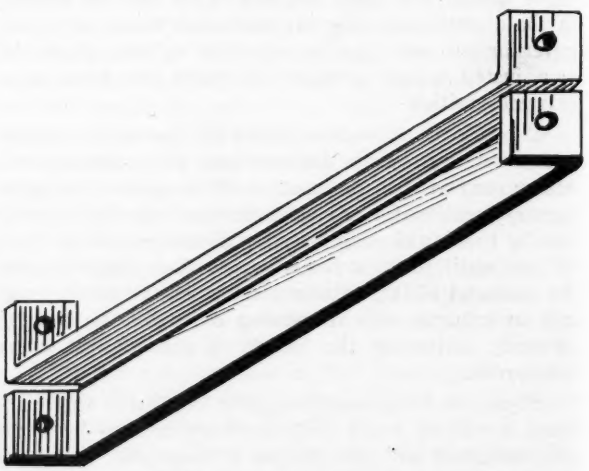
SOME TIME AGO, the crosshead strap on the high-pressure side of a large engine broke while the engine was under load and knocked out the cylinder head. Although the head was badly cracked, it did not fall to pieces. As we had no cylinder head on hand and needed the engine badly, we decided to try using the cracked head.

After repairs were made, this cracked cylinder head was put back on the cylinder and a little steam admitted to the cylinder to see how badly it leaked. It was decided, however, that it was dangerous to use the cracked head without supporting it in some manner, so a piece of 8 by 8-in. timber was set between the cylinder head and a 13-in. thick brick wall which was about 4 ft. from the cylinder head and a screw-jack was used to take up the slack. After tightening up on the jacket to get some pressure on the head, the engine was put under load. Other than small leaks of steam every time the engine took steam on the head end, the head served its purpose until a new head could be ordered.

Boyles, Ala. E. O. EDNEY.

Fastening Angle Iron Endwise

FASTENING a piece of angle iron endwise may be simply and neatly done by making a hacksaw cut through the angle, not less than the width of the iron.



SIMPLE AND NEAT SUPPORT FORMED OF ANGLE IRON

Heat and bend the flat level side, UP and the lower upright part, IN. If the iron has to carry a heavy weight, the lower part when bent in gives a better support than if bent outward.

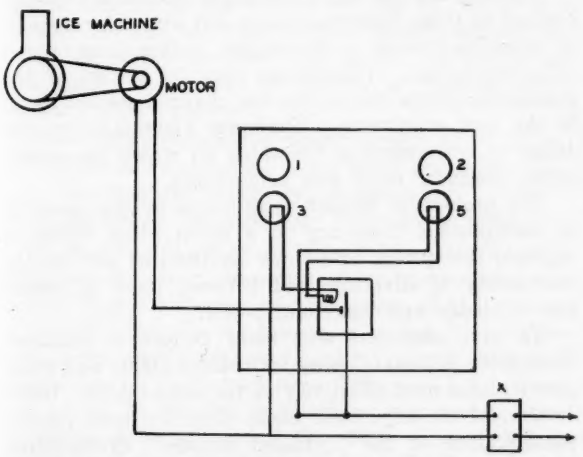
Death Valley, Calif. CHAS. LABBE.

Questions and Answers

No-Voltage Release Installation Eliminates Belt Slippage

IN OUR PLANT we have a small 5½ by 5½-in. single acting ice machine belted to a 15-hp. direct current motor operating at 230 v., and 59 amp. This motor is over 1000 ft. away from the engine room and there is no voltage release connected in the line.

When attempting to start the ice machine, without going over to pull the ice machine switch which is 1000 ft. away, after it has been suddenly shut down as, for example, when the main switchboard breaker blows,



BELT BURNING PREVENTED BY INSTALLING A NO-VOLTAGE RELEASE IN LINE

the pulley rotates without carrying the belt and thus burns it and fills the room with smoke. Under these conditions, the discharge pressure of the ice machine is about 120 lb. while the suction pressure is 15 lb. The ice machine and motor are controlled automatically from an electrical switchboard of its own which is supposed automatically to start and stop the machine at certain brine temperatures.

Could a no-voltage release be connected to this automatic arrangement so as to cut the machine out of the line when anything goes wrong in any part of the plant? If so, how could it be connected in? M. J. M.

A. Your analysis of the conditions, we believe, is quite accurate. The reason the belt burns out repeatedly is due no doubt to the fact that once the motor is stopped it cannot start the machine again under the high head or discharge pressures which may exist at the time. The remedy is to incorporate a device in your switchboard arrangement which will prevent the motor from restarting automatically when the current comes on again after an interruption. This may be accomplished by means of a no-voltage release in connection with a small circuit breaker or perhaps a rheostat.

In the accompanying diagram, an arrangement is shown which would accomplish automatic control operations stated by you. Devices 3 and 5 which you have indicated in your sketch are probably contact making devices operated by pressure gages. These two devices are apparently in series with a magnetic coil on the main contactor, No. 7.

A circuit breaker or rheostat could be included as shown at X. This circuit breaker would include a small magnet excited from the main direct current circuit which would keep the circuit closed against the action of a spring. If the voltage failed, the magnetic attraction would be lost and the spring would open the circuit. It is assumed that when the voltage came on again, the distance between the magnet and the armature of this circuit breaker would be such that the magnetic attraction could not overcome the action of the spring and the circuit would have to be closed by hand.

Extraction Steam: Quantity and Pressure

WE HAVE A 1500-kw. steam turbine extracting steam from a high-pressure stage at about 25 lb. There is a 14-in. multiport, non-return valve in the extraction line with 4-lb. springs. Formerly we used lighter springs, about 2 lb. These were replaced by the heavier springs to maintain a differential pressure in the extraction line of 4 lb. so that when we have 25-lb. pressure on the turbine side of the nonreturn valve there is a pressure of 21 lb. on the other side.

Often it is desirable, for process work, to maintain a higher pressure in this line but, as we are running the turbine to the limit of its capacity, this is impossible under the present method of operation. If the 2-lb. springs were again put in the nonreturn valve, would not this raise the pressure of the steam as desired? Would this affect the quantity of steam extracted? If so, how? Our extraction line is 400 or 500 ft. long and the pressure at the throttle is 235 lb. C. L.

A. Replacing the 2-lb. springs for the 4-lb. springs now in the nonreturn valve will raise the extraction pressure 2 lb. but under this condition you would reduce the quantity of steam that would be discharged at the higher pressure.

If you are not restricted in the amount of steam required by your present maximum output, the rise in pressure to 23 lb. would answer your purpose and it would be worth while to make the change. Since the loss in volume would not be great and the change can be made easily, why not try it out and determine directly if a sufficient amount of steam is supplied?

Editorial Comment

The Mechanized Coal Mine

For many years to come, coal will probably be our principal fuel, as it is today. The power engineer, in most cases, does not care a great deal how coal is mined unless the processes and methods of preparing the coal for the market have some influence on its characteristics as a fuel. As an engineer, however, he should certainly be interested in the fact that a tremendous increase has taken place in the amount of coal that is mined and handled by machinery.

From 21,559,000 t. in 1928, the production of bituminous coal by mechanized mining has increased to 37,862,000 t. in 1929, a growth of over 75 per cent, according to the Coal Division of the Bureau of Mines.

Practically all phases of technologic improvement in mining, such as cutting machines and electric haulage, are forms of mechanization. The discussion of "mechanization" now going on in the American coal industry, however, centers around the use of mechanical devices to reduce the labor of hand shoveling into mine cars and the following statistics are designed to show how far the replacement of hand loading had progressed by the end of 1929. The figures are taken from a special study by O. E. Kiessling and L. Mann of the bureau which will later be published in detail.

The total of 37,862,000 t. relates only to operations underground. It does not include coal loaded by power shovels in strip pits which amounted to approximately 22,000,000 t. in 1929. Neither does it include anthracite, 3,427,000 net tons of which were mined mechanically in 1929, according to the Pennsylvania Department of Mines. It is also important to note that the figures represent production and not capacity. The total is undoubtedly much less than the annual capacity of the machines installed up to the end of 1929, partly because production seldom reaches theoretical capacity. Many of the machines used in 1929 were installed late in the year and so had little effect on the tonnage for 1929.

Of the total tonnage handled mechanically, 43.4 per cent was loaded by mobile loading machines, 41.1 per cent by scraper loaders, 39.6 per cent by pit-car loaders, and 12.9 per cent by conveyors, including duckbills.

Although the coal produced by machinery as noted above constitutes only a small part of the total coal produced during the year, the increase of 75 per cent in one year in that machine-produced coal is significant. If that increase continues at anywhere near the same rate for a few years, the resulting methods of coal production may have important influences on fuel supply.

What might its effect be on the price of coal, the amount of coal that must be kept in storage, the "capacity factor" of the mines and similar factors? What changes might it bring about in the number of men required to mine a given amount of coal, the relations between mine labor and operator? What would be the social implications of a mining industry more fully mechanized, even as other basic industries such as agriculture, lumbering and even fishing, are being mechanized?

It is obviously too early to answer such questions adequately. But to the power plant engineer whose principal raw material is coal, the entire problem should stimulate thought that may bear interesting fruit.

Some Modern Works of Art

Nothing is certain except change, especially in engineering and no change has been more far-reaching in both its social and its technical results than the development of the great modern power distribution systems, each of them tremendous in itself and still more tremendous when its interconnections with other systems are taken into account.

Not only has the entire method of operation changed because of these interconnections but also the emphasis in operation is now on the system, rather than on the individual plant. This means that the design of the generating plants themselves has changed materially to fit the new conditions. Maximum kilowatt-hours per dollar of investment is the thing on which the public utility engineer must now concentrate.

The problem is further complicated by the necessity of maintaining frequency in a given plant either to regulate the system or to stay on the line and by the desirability of dividing load between units to secure best efficiency and maximum power.

To give engineers still more factors to consider, there is the method of using both steam plants and water power plants most effectively on the same system. Introduction of the adjustable blade propeller type runner, consideration of the "pumped storage" hydroelectric plant, proper use of run-of-river plants and so on, not to mention the electrical switching and distribution problems, all add their color to the picture.

It is not a picture that can be taken in at a glance; it must be studied carefully in all its details. But it is, after all, an integrated whole and it requires a master artist to assemble the forms and colors in their proper relations.

To obtain some idea of the type of problems involved, study of the article on Frequency and Load Control by S. Logan Kerr in this issue will prove most stimulating. A good idea of the larger problems of modern hydroelectric developments can also be obtained from the descriptions given in our May 15 issue of the developments on the Mokelumne River in California and of the Mongaup River in Southwestern New York State. The latter project is especially noteworthy.

Study of these and similar articles show a picture of public utility systems much different from that observed 10 or 15 yr. ago. The modern picture, much more colorful and interesting, will change, of course, but the painting of it by the public utility engineers constitutes probably the most important achievements of modern civilization.

Off Duty

There has been great argument of late among various gifted gentlemen whose names not infrequently adorn the pages of our intellectual periodicals, about the general subject of religion. Aside from the edification they themselves derive from it, this is perhaps of little importance. Religion always has been a fertile subject for discussion and more than once in the history of the world has led to hard feelings; sometimes even to blows. These recent discussions, however, being between gentlemen, have been quite devoid of bloodshed and although the participants seem to differ as to the cause, they are all fairly agreed, as Edward S. Martin puts it, that religion is going, or has gone to the bow wows and that human conduct must find some other basis. Each of these gentlemen naturally has some pet theory to offer as a solution and that is the reason for all the argument. In the meantime, the poor pilgrim, unable to swallow orthodox theology, has a hard time in finding his way about in the debatable ground where, in the words of one of the above gentlemen, the frontiers of science, morals and theology meet.

In introducing this subject, we do not, necessarily, wish to engage in the controversy for at best it is a delicate one and we have worries enough without inviting the wrath of those who might differ with us. Like Omar, we realize the futility of arguing about religion; indeed, we too

"—— when young did eagerly frequent
Doctor and Saint, and heard great argument
About it and about; but evermore
Came out by the same door where in we went."

So, yielding the floor to Messrs. Lippman, Fosdick, Davis and the others, we shall confine our remarks to a quite different although related aspect of the subject.

It seems that, in the absence of a definite religious basis, most people are repelled by a purely biological explanation for their existence. Science is a fine thing, they admit, for accounting for the existence of the sun, the earth, or in explaining the shape of a crystal or predicting the reaction between chemicals; but when it comes to explaining the human being, they scorn "gross materialism" and grope vainly for something "spiritual."

Now, we do not condemn anyone for seeking the spiritual; spiritual matters have a definite place in human thought but that is no reason for blindly denouncing materialism. The word, materialism, for some reason is in bad repute; we call everything bad, everything undesirable, "material" while those things which we exalt and hold in high esteem, we term "spiritual."

Materialism in the sense we wish to consider it here, is not that materialism by which we imply the selfish pursuit of pleasure, but that by which we find an explanation of the great processes of life in terms of physical and chemical reactions—that which Jacques Loeb called the mechanistic conception of life. Loeb was perhaps the greatest exponent of practical materialism that ever lived, the thesis upon which he worked being that all living things are chemical machines and that their workings are open to the same mechanistic explanation as those of machines made of inert matter. The results of his researches went far to prove the correctness of his theories.

Man is an arrogant creature. Not content with being merely a part of the universe in which he finds himself, not satisfied to account for his existence in terms of the laws which govern the rest of the universe, he seeks to make himself the sole excuse for the universe; he thinks himself its highest product. This thought, of course, tickles his vanity but it may not be true; in fact, from what we have been able to observe, the universe is very unconcerned about man. As Jeans suggests, life may be a mere accidental and purely unimportant by-product of natural processes which have some other and more stupendous end in view—or it may be nothing more than a disease which afflicts matter in its old age.

If we could forget our desire to establish direct relationship between ourselves and the ruling power of the universe and accept a little more of the materialistic or mechanistic view of life, we should all be happier for it and perhaps would understand each other better. Such an acceptance of materialism need not soil the sense of that which is spiritual but would rather tend to keep it pure by not loading upon it those things which we can work out for ourselves.

Instead of attributing our acts to the good or evil spirits which inhabit our souls, let us consider ourselves machines and let us seek explanation for our acts in the reactions of the component parts of these machines. Science has only touched the outer edge of these things and yet it has gone farther than is dreamed of by those who do not know the language. Pawlow's experiments on conditioned reflexes in dogs, Loeb's work on the heliotropic and galvanotropic reactions of fish and plants, Bovie's studies on the reactions of the amoeba to radiation, all furnish abundant evidence that this theory is not an idle dream.

Applied to human beings, the mechanistic conception would make us more tolerant. It would make us less harsh in judging others—our judgment would depend not alone upon whether or not a person committed a certain act but would rest upon the reactions which led to that act. With more materialism there would be less hate, less anger. If we could be shown the whole process of anger, of the poisons secreted under it and the nerve reactions whereby understanding is inhibited, we should be sorry for the angry person; we would know that his wrath is a pathological condition and treat him accordingly.

We would find that people do things, not necessarily because they deliberately set out to do these things but because they cannot help themselves. Under certain conditions, certain fish will swim toward light. This is not curiosity on their part for it is brought about by adding certain chemicals to the water in which they swim. They cannot help themselves, but are impelled toward the light by certain photochemical reactions which take place in their nervous system.

In the same way, the reactions of human beings are due probably to certain stimuli and with a materialistic philosophy we should seek the stimulus for each reaction; we should think less about free will and more about chemistry and physics. In short, we should display a far more intelligent attitude in forming opinions about others. This in turn would aid that mechanism in ourselves which functions as sympathy and we would thus be better equipped to judge rightly and kindly.

Power Plant Engineering Developments and News

Bremo Bluff Plant to Have Interesting Features

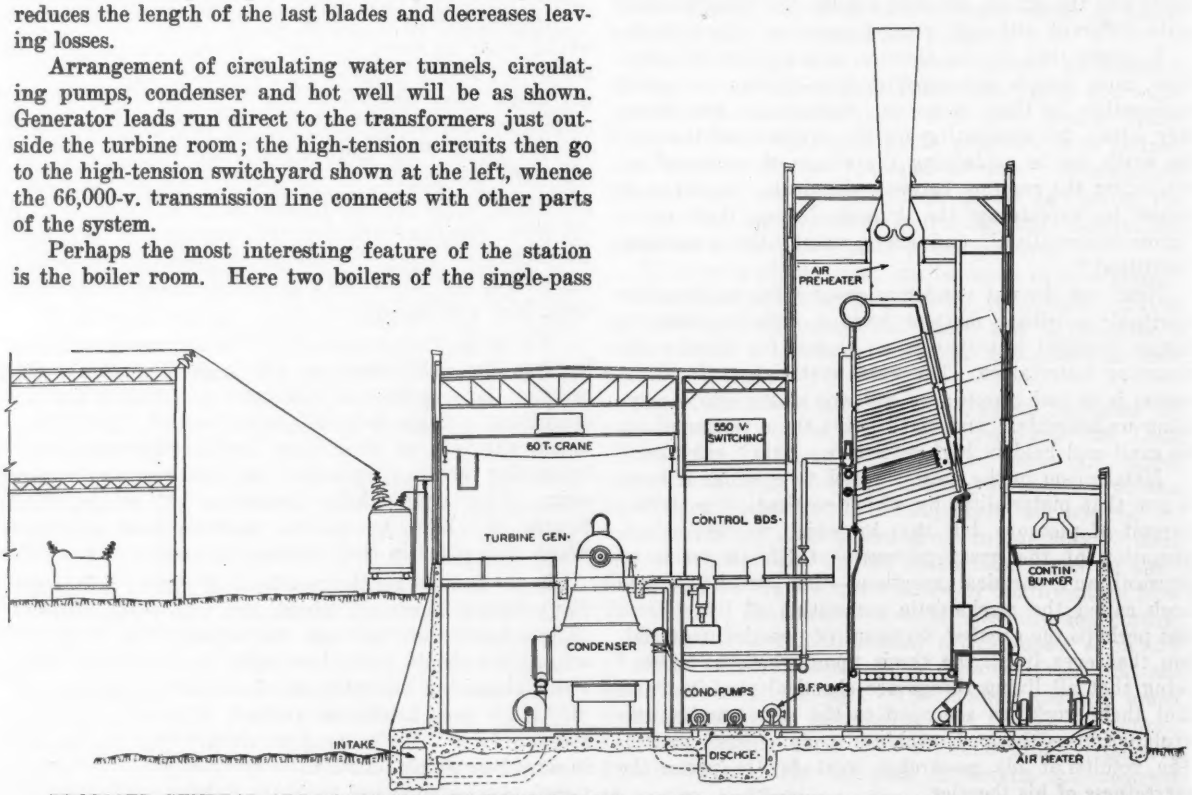
AS NOTED on page 629 of the June 1, 1930 issue of Power Plant Engineering, the Virginia Public Service Co. has begun construction at Bremo Bluff, Va., on the James River, of a new steam power plant with an initial capacity of 30,000 kw. in two units. The accompanying drawing shows the proposed general arrangement of the station.

The two turbine generators, of 15,000-kw. capacity each, are to be of the tandem-compound type, with double-flow low-pressure cylinders. They are designed for operation at 450 lb. throttle pressure and a total steam temperature at first of 750 deg. Provisions are made in the design, however, for future operation at a higher temperature and the tandem-compound turbines are used so that when the temperature is raised, the high-temperature steam will come in contact only with the comparatively small high-pressure cylinder. Use of the double-flow principle on the low-pressure cylinder reduces the length of the last blades and decreases leaving losses.

Arrangement of circulating water tunnels, circulating pumps, condenser and hot well will be as shown. Generator leads run direct to the transformers just outside the turbine room; the high-tension circuits then go to the high-tension switchyard shown at the left, whence the 66,000-v. transmission line connects with other parts of the system.

Perhaps the most interesting feature of the station is the boiler room. Here two boilers of the single-pass vertical type will be installed at first, with space left for a future third boiler. Each boiler consists of three banks of inclined straight tubes, without baffles, one bank above another, with the convection superheater between first and second banks. The furnace, completely water-cooled, has a slag tap bottom. Combustion gases pass directly upward in a straight line through the boiler. The upper tube banks are shorter than the lower and the passage contracts gradually to accommodate the reduced volume of gas. The products of combustion pass from the boiler through an air preheater of a new type, details of which cannot be divulged at this time. They pass then to the induced draft fans and stack; this stack is of the venturi type with the fans and gas passages designed as an integral part of the stack. It is stated that the draft loss from furnace to stack in this arrangement is only 2 in., representing a material decrease in fan power for a given steaming capacity, as compared with usual boiler arrangements.

Furnaces are fired with pulverized coal, three burners and three pulverizers being provided for each



PROPOSED GENERAL ARRANGEMENT OF NEW 30,000-KW. PLANT AT BREMO BLUFF, VA., ON JAMES RIVER

boiler. Each burner is supplied with coal by its own pulverizer, the object being to secure accurate control of the flame over the entire width of the furnace under all conditions of load. Pulverizers are to be of the ball type fed from an overhead bunker as shown.

To secure accurate control of combustion, coal and primary or carrying air are premeasured before going to the pulverizers and preheated secondary air is measured before going to the burners. Carrying air to the pulverizers is heated, of course, to effect any coal drying that may be necessary in the mills.

Between the turbine room and boiler room, at the turbine level, is the control room, where all controls for turbines and boilers are brought to centralized boards, so that one operator can control all equipment. The boiler controls especially incorporate many new and advanced features.

Below the control room is a floor containing extraction feedwater heaters of new design, as well as evaporators. There are four extraction heaters per turbine, designed to give proper water temperatures at all loads on the turbine from zero load to overload conditions.

Below the heater room is the pump room, containing condensate pumps and boiler feed pumps.

The Bremo Bluff station is designed for low coal consumption, high overall efficiency in operation and simplicity and ease of handling.

Electric Management & Engineering Corp., 57 William St., New York, are engineers and constructors of this power plant for the Virginia Public Service Co.

Burner of New Design

TWO DESIRABLE conditions for burning certain fuels are uniform velocity on leaving the burner regardless of the amount of fuel and maintenance of turbulent flow. In most installations, fuel feed must be varied according to demands for heat energy. This can be done either by varying the number of burners in use or varying the opening through the burner, if velocity of issue is to be maintained.

In the new A. & D. Adjustable Orifice Burner, Fig. 1, the delivery opening of the cone can be varied in diameter by movement of the outlet end of 12 adjustable vanes toward or away from each other, the other ends being hinged to the shell of the burner and movement controlled by a series of toggle joints to a stem, sliding lengthwise of the burner in the conical casing

FIG. 3. ARRANGEMENT OF INSTALLED BURNER AND FUEL SUPPLY FAN

shown in Fig. 2. Operation of the plunger is by the handwheel at the left of Fig. 2, through spiral gears driving a stationary nut and with indicator to show the opening of the burner orifice at all times.

As seen in Fig. 1, turbulating vanes are attached to the adjustable longitudinal vanes. Six outer vanes lap the edges of the adjustable vanes, being held in contact at all times by rocking plungers forced inward by the springs seen around the burner shell in Fig. 2. This gives a tight nozzle at all times, regardless of orifice, size and of constant area at the hinged end. Outside the adjustable nozzle is a sleeve, with vanes spiraled in the opposite direction to those in the nozzle, for admission of secondary air. The position of the sleeve can be adjusted lengthwise to give the best conditions, the amount of air being regulated by openings in the casing, controlled by the handwheel at the right, Fig. 2.

Back of the air-control ring is a cleaning ring which carries the outside vanes and is made in halves for convenient removal. It has also auxiliary air dampers through which preheated air may be admitted, if desired.

In the section behind the cleaning ring a steel liner is fitted, which makes a sealed joint with the fixed end

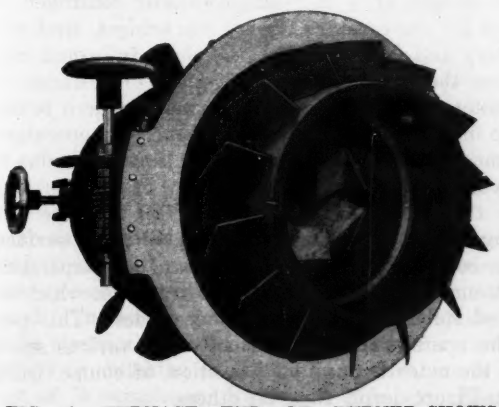


FIG. 1. FURNACE END OF BURNER SHOWS ADJUSTABLE ORIFICE VANES AND AIR SLEEVE

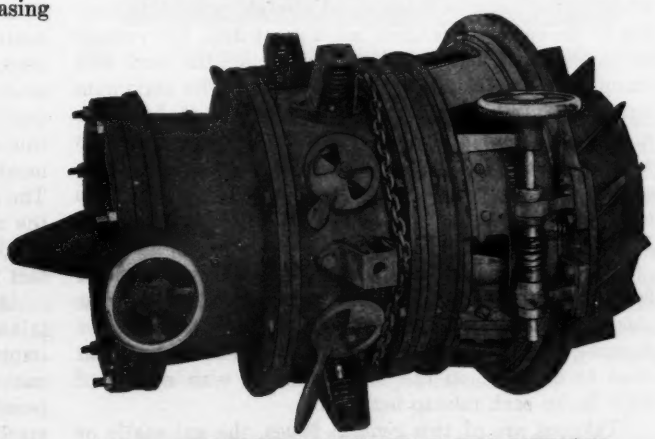


FIG. 2. SIDE VIEW OF BURNER, CASING CONSTRUCTION AND CONTROLS

of the vanes so as to give smooth flow of the air and fuel mixture into the nozzle.

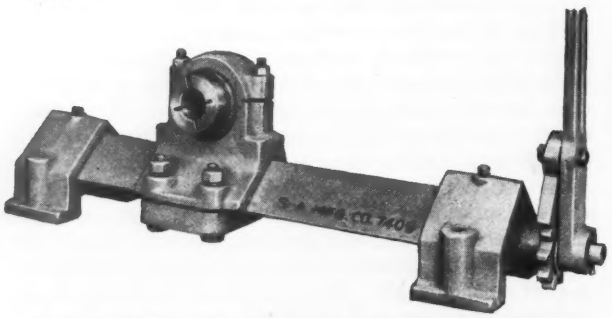
Figure 3 shows the burner as installed with fan for feeding the air-fuel mixture. But one burner is used in a furnace, regardless of size, the A. & D. burner being made in four sizes to handle from 986 to 41,072 lb. of coal an hour.

If desired, the adjustment of orifice opening can be operated by the same control as fuel feed and air supply, thus giving completely automatic combustion control from steam pressure or other condition of the service.

Size of burner, disposition of secondary air vanes, location of burner in the furnace are recommended by the manufacturers to give best results for conditions to be met. The burner is the design of The Ashmead-Danks Co. of Cleveland, Ohio.

New Conveyor Bearing

IN ANNOUNCING a new roller bearing belt conveyor takeup bearing, Stephens-Adamson Mfg. Co. of Aurora, Ill. calls attention to some interesting figures in regard to belt tension and stretch, in belt conveyor design.



NEW ROLLER BEARING BELT CONVEYOR TAKEUP BEARING

Ordinarily a belt conveyor consists of a wide endless belt, the upper surface of which carries the load and is supported by idlers spaced every 4 or 5 ft. The belt is usually driven by the head pulley and a certain amount of tension must be maintained to give the required traction to the drive pulley.

Although conveyor belts are carefully stretched when made, there is a continual stretching or lengthening as the conveyor is used, not a great deal, but enough to necessitate a takeup pulley to eliminate the slack and maintain a fairly uniform belt tension. The maximum tension advisable varies with the width of belt, the number of plies and the weight of the duck used to reënforce the belt. As an example, the maximum tension for a 42-in. conveyor belt of 8-ply, 32-oz. duck is approximately 9072 lb. as compared with 1152 lb. for a 12-in. belt of 4-ply, 28-oz. duck.

In the normal 42-in. belt conveyor, this tension of 9072 lb. is the belt pull at the driving pulley. On the slack or tail end of the conveyor, the tension will have decreased to about 3000 lb. This means a total pull of close to 6000 lb. on the takeup pulley with a load of 3000 lb. on each takeup bearing.

Takeups are of two general types, the automatic or gravity takeup pulley for long and heavy duty conveyors and the screw type for shorter belts. The screw takeup consists of a bearing which can be pulled backward on its base as the belt stretches and is generally satisfactory for conveyors up to 200 ft. in length. These bearings vary in size to suit the pulley shaft and in maximum bearing travel to suit the length of the conveyor. As it is considered good conveyor design to provide a takeup travel of about 2 per cent of the conveyor length, a 12-in. adjustment would be suitable for conveyors up to 50 ft. in length while a 54-in. takeup bearing should be adequate for most belt conveyors up to 225 ft. long.

This new Stephens-Adamson takeup bearing consists of a structural steel angle, upon which slides a Timken bearing in a special self-alining housing. The bearing is moved backward or forward by a screw, protected by a steel angle and is operated by a ratchet lever designed for use in cramped quarters. The takeup is furnished for shafts from $1\frac{1}{16}$ up to $4\frac{1}{16}$ in. diameter and in sizes with a maximum shaft travel of 24 to 54 in. The inner race is fitted with an adapter which receives the shaft without turning or shouldering.

Master Switch for Magnetic Contactor Control

EMBODYING SEVERAL new features, the master switch shown in the accompanying illustration, being manufactured by the Electric Controller & Mfg. Co. of Cleveland, Ohio, should find many applications.

ELECTRIC CONTROLLER & MFG. CO. MASTER SWITCH

This switch, the function of which is to regulate the control circuits of a magnetic contactor controller, is intended for use on cranes, hoists, ore bridges, steel mill machinery and other applications where full-speed control from the master switch is desired. The design of this master switch incorporates the most modern refinement to insure the utmost in smooth and easy operation. The almost frictionless operation of this switch is due to the use of ball bearings, the short throw of the operating handle, the absence of gears and the fact that the contact fingers always ride on uninterrupted plane surface.

Also contributing to the smooth and even operation is an accurately machined, notched track, on which an improved roller-type centering device rides. This permits the operator to feel distinctly the various speed points, the notch in the "off" position, of course, being machined more deeply than the others.

Particular attention has also been given to make the

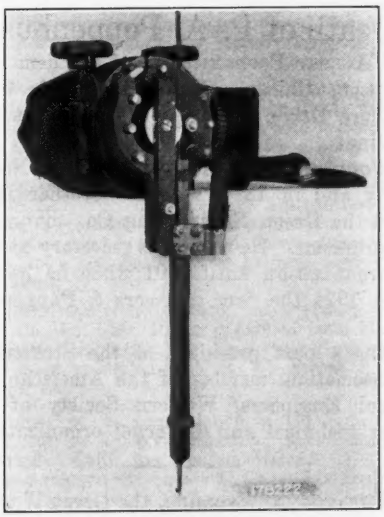
width of the switch as small as possible, so that when several of them are mounted in a crane cage or operator's pulpit the operator can, without moving his position, conveniently reach and operate them. Other outstanding features which appeal strongly to crane operators are the straight line lever operation, the short throw of the handle and the fact that it can be mounted in the upright or the inverted position which permits a close grouping of a number of these master switches.

As shown, this master switch is entirely enclosed by heavy gage steel cover and is arranged for conduit connection. Both the contacts and contact fingers are of a greatly improved design and are easily renewable.

These switches are built to give a maximum of six points of speed control in each direction with overload reset at the "off" position. Master switches for 4, 5, or 6 points of speed control are identical, the only difference being the location of the arm stops. Since these stops are merely screwed into the main frame, they can be readily changed in the field to provide any one of these numbers of points of speed control, thereby reducing the spare part problem.

Weldomatic Arc Welding Head

DURING the past year the Westinghouse Weldomatic arc welding head has been developed, as shown. This is designed so that the speed of the motor which drives the welding wire is continually controlled by the arc conditions so that the welding wire will always be fed at exactly the right rate, as determined by the fusion of the electrode. This speed control is designed to be perfectly continuous, and automatically to vary itself over a wide range and to take care of ordinary changes in the arc circuit itself and of relatively wide changes,



WELDOMATIC ARC WELDING HEAD

such as appreciable change in current adjustment over wide limits and changes in sizes of welding wire, which also necessitates changes in the current that is being used. The entire control is designed to obtain its results electrically to obviate the necessity for any control relays or clutching or ratcheting devices. It is a product of Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

New Crawler Loader

LINK-BELT CO., Philadelphia, Pa., announces the development of a new high-capacity crawler bucket loader, which is to be known as the Grizzly, 1930 Model, and that, after having given the machine a thorough

FIG. 1. SCREW TYPE SELF FEEDER

tryout under actual working conditions, it will begin production on a large scale.

The self-feeder with which the loader is equipped, shown in Fig. 1, is of the continuous helical ribbon type. The action of its self-sharpening spiral and cutting edge serves to cut, dig and convey the material to the elevator buckets in a smooth, continuous, uniform stream, feed adjustment being controlled by a hand-wheel within easy reach of the operator, who rides with the machine

FIG. 2. FEEDER, ELEVATOR AND POWER DRIVE FORM A SINGLE UNIT

on a conveniently located side platform, Fig. 2. Capacity of the machine is 1¾ cu. yd. per minute for sand, stone or gravel, 1½ in. and smaller, run-of-mine coal and coke. Larger stone may be handled at a somewhat smaller capacity.

The power unit regularly includes a 30-hp. Buda gasoline engine, or a 20-hp. electric motor, for operating the bucket elevator, the feeder and the crawler traveling mechanism. The crawler is wide and long to give the machine ample stability for the grueling work to which such machines are customarily subjected.

FUEL SAVING of equipment when measured in dollars is less with low-priced coal than with high-priced coal.

A. S. H. & V. E. at Minneapolis June 24-27

FOR THE ANNUAL SUMMER MEETING of the American Society of Heating and Ventilating Engineers, to be held June 24 to 27 at the Curtis Hotel, Minneapolis, Minn., a varied program of entertainment and technical papers has been prepared. Complete details may be obtained from the Secretary of the Association at 51 Madison Avenue, New York City, or from Albert Buenger, Chairman, Committee on Arrangements. The program as announced for the meeting is as follows:

Tuesday, June 24

8:30 a. m.—Registration, Curtis Hotel.

9:30 a. m.—Report of Committee on Meeting Programs by A. C. Willard, Chairman.
Control Equipment for Gas Burning Appliances by W. E. Stark.
Economic Use of Steam in Modern Buildings by F. A. Gunther.
Report of Guide Publication Committee by D. S. Boyden, Chairman.

Wednesday, June 25

9:30 a. m.—Report of Committee on Research, F. B. Rowley, Chairman.
Report of Director of Research Laboratory by F. C. Houghten.
Surface Conductances as Affected by Air Velocity and Character of Surface by F. B. Rowley.
Wall Surface Temperatures by A. C. Willard and A. P. Kratz.
Comfort, Wall Temperatures and Insulation by Paul D. Close.

Thursday, June 26

9:30 a. m.—Report of Committee on Oil Burning Devices by L. E. Seeley, Chairman.
Report of Committee on Pipe Sizes for Heating Systems by H. M. Hart, Chairman.
Capacity of Return Mains for Gravity and Vacuum Steam Heating Systems by F. C. Houghten.
Loss of Head in Submerged Orifices by F. E. Giesecke.

Friday, June 27

9:30 a. m.—Air Infiltration through Various Types of Wood Frame Building Construction by G. L. Larson and D. W. Nelson.
Report of Committee on Garage Ventilation, E. K. Campbell, Chairman.
Carbon Monoxide Concentration in Garages by A. S. Langsdorf.
Report of Committee on Air Cleaning Devices by O. W. Armspach, Chairman.
Air Conditioning in the Modern Bakery by W. L. Fleisher.
Report of Committee on Air Conditions and their Relation to Health, W. H. Carrier, Chairman.
Report of Nominating Committee.

One and a Half Million Horsepower

TWO TRANSFORMERS which for two seconds have a capacity of 1,250,000 kv-a.—well over a million and a half horsepower—have been installed at the Schenectady works of the General Electric Co. This maximum capacity is more than twice as great as the installation of the Niagara Falls Power Co., which is rated at about 556,000 kv-a.

These transformers, which will be used with a 100,000-kv-a. generator, are normally rated at 33,333 kv-a. and are the largest yet built for testing work. They are to be used for testing switchgear of various types. The two transformers now installed are the nucleus of a bank of four.

Each transformer weighs 200 lb. less than 200 tons, including 27,200 gal. or 100 tons of oil. The weight of the core and windings is 64 tons. The long diameter is 21 ft. 8 in., and the short diameter 12 ft. 2 in. There are 13 high voltage bushings on the top of each for ease in obtaining different voltage connections. The overall height is 28 ft., 1¼ in.

In shipment from Pittsfield, Mass., the place of manufacture, to Schenectady the cores and windings were enclosed in steam-heated houses on standard transformer cars. A temperature of 90 deg. F. was maintained so that the cores arrived at Schenectady free from moisture.

E. G. Bailey Receives Longstreth Medal

AT THE MEDAL DAY exercises held May 21 in the Hall of the Franklin Institute at Philadelphia, Pa., Ervin G. Bailey, President of the Bailey Meter Co., Cleveland, Ohio, was awarded the Edward Longstreth medal by the Institute. Mr. Bailey received the medal upon the recommendation of the Institute's Committee on Science and Arts in recognition of his many inventions and developments of regulating and controlling devices and of measuring and recording instruments.

Mr. Bailey was graduated in mechanical engineering from Ohio State University, Class of 1903. He holds many patents on instruments and equipment used in the combustion field. He is a resident of Easton, Pa., and is also president of the Fuller Lehigh Co. at Fullerton, Pa., and a director of the Babcock & Wilcox Co. of New York.

Death of P. A. Poppenhusen

PAUL ALBERT POPPENHUSEN of the firm of Acers & Poppenhusen, Chicago, Ill., died at his home, 6930 South Shore Drive, Chicago, on May 24, after an extended illness.

Mr. Poppenhusen was a graduate of Northwestern University and in 1894, with his brother Herman, he organized the Green Engineering Co., manufacturer of stoker equipment. He served as secretary and treasurer of this organization until 1901 when he became president. In 1924 the firm of Acers & Poppenhusen was formed.

He was a past president of the Stokers Manufacturers Association, member of the American Society of Mechanical Engineers, Western Society of Engineers and other technical and fraternal organizations.

AT WHEATLAND, Wyoming, the Great Western Sugar Co.'s new beet sugar refinery is nearing completion. The boiler house, designed to serve this factory will contain three B. & W. Stirling water tube boilers fired by B. & W. stokers. A Sauerman drag line coal handling system will be installed and ash will be handled by a sluice. Electric power will be obtained through the U. S. Bureau of Reclamation from the Guernsey Power Plant about 30 mi. away. R. G. Miller of Great Western Sugar Co. is superintendent of construction and H. E. Faust is master mechanic.

News Notes

BLAW-KNOX Co., Pittsburgh, Pa., announces the addition to its sales staff of John E. Chiquoine. Mr. Chiquoine is a graduate of the University of Pennsylvania, later taking part in the World War in the air service. He has been connected successively with the American Chemical Machinery Co., of which he was chief engineer and with the Industrial Engineering Division of E. I. Du Pont de Nemours & Co.

SINCE April 26, 1930, Indianapolis office of Dearborn Chemical Co. has been located at 823-824 Occidental Building, Illinois and Washington Sts. Indianapolis, Ind.

APPOINTMENT of six new distributors, each of whom will carry a complete stock, is announced by Tube-Turns, Incorporated, Louisville, Ky. The new distributors are the Grinnell Co., at Charlotte, N. C., for North and South Carolina and Georgia; Ebbert & Kirkman Co., Inc., of Birmingham, Ala., for Alabama; the B. Hoffmann Manufacturing Co., of Milwaukee, for Milwaukee and adjacent territory; the United Pipe & Supply Co., of Charleston, W. Va., for Charleston and adjacent territory; the Vulcan Copper & Supply Co., of Cincinnati, for Cincinnati and adjacent territory; and Hedley & Voisinet of Buffalo, for Buffalo and surrounding territory.

JOHNS-MANVILLE CORP. has announced the purchase of the assets and patents of the Stevens Sound Proofing Co., of Chicago, manufacturers of patented structural products for sound insulating in walls, floors and ceilings, and for constructing anti-vibration platforms under machinery. The acquisition of these products makes an important addition to the present line of Johns-Manville acoustical material.

LINK-BELT Co., Crane & Shovel Division, 300 West Pershing Road, Chicago, announces appointment of the following companies as direct representatives: W-D-M Equipment Co., Columbia, South Carolina; Myer & Cunningham, 30 Church St., New York, N. Y.; Barzee Equipment Co., 1223 Burnet Ave., Syracuse, New York; S. G. Hawkins Co., 723 Washington Ave., Houston, Texas; Lewis-Patten Co., San Antonio, Texas; West Virginia-Kentucky Hardware & Supply Co., Huntington, W. Va.

OXFORD PAPER Co., Rumford, Me., has placed contract with the Morton C. Tuttle Co., of Boston, to manage the construction of a large power house, the work to start immediately. Charles T. Main, Inc., of Boston, are the designing engineers.

F. G. BARNETT, formerly assistant manager of the Maine-New Brunswick properties of the Central Public Service Corp., has assumed his duties as manager of the electric division of the Rockford (Ill.) Electric Co., subsidiary of Central Public Service, succeeding Charles S. Gillette, who recently resigned to accept a position in Chicago.

IOWA RAILWAY AND LIGHT CORP., Cedar Rapids, Iowa, will proceed with its $375,000 power plant on the Tama-Toledo corporation line, according to Sutherland Dow, vice president of the utility, despite the defeat of its application for a gas franchise in Tama recently. The new automatic substation will be modernly equipped in every detail with a 1200-hp. Diesel engine supplying first unit. It has been ordered for delivery Sept. 30 and the plant is expected to be in operation by the first of the year. The Tama unit will supplement the three principal power plants at Cedar Rapids, Marshalltown and Boone. Two or three more units will be added as necessary.

PAUL E. ILLMAN was recently elected vice president of Dwight P. Robinson & Co., Inc. Mr. Illman graduated from Harvard in 1909, was formerly vice president of the Peoples Bank of Buffalo and has lately been connected with S. W. Straus & Co. and Charles F. Noyes Co.

MERGER resulting in the consolidation of the Square D Co., Detroit, Mich., and the Diamond Electrical Manufacturing Co., Inc., of Los Angeles, Calif., has been announced.

Under the new merger, the Square D Co. will be controlled by the same executive personnel, with the addition of Vernon Brown and J. H. Pengilly of Los Angeles as vice presidents.

STOKER MANUFACTURERS ASSOCIATION, at its annual meeting at the Manufacturers Country Club, Philadelphia, Pa., on May 23, elected the following officers: President, Joseph G. Worker, American Engineering Co.; Vice President, William F. Turner, Flynn & Emrich Co.; Secretary, William V. McAllister, Riley Stoker Co.; Treasurer, F. H. Daniels, Riley Stoker Co. Two new member companies were admitted: Combustioneer, Inc., Goshen, Ind.; Auburn Stoker Co., Auburn, Ind.

Companies represented at the meeting by their presidents were: American Engineering Co., Philadelphia; Babcock & Wilcox Co., New York; Combustion Engineering Corp., New York; Detroit Stoker Co., Detroit; Riley Stoker Corp., Worcester; Westinghouse Electric & Mfg., Pittsburgh; Flynn & Emrich, Baltimore; Burke Engineering Co., Chicago; Laclede Stoker Co., St. Louis; Combustioneer, Inc., Goshen, Ind.; Auburn Stoker Co., Auburn, Ind.; Illinois Stoker Co., Alton, Ill.

DAMPNEY CO. OF AMERICA of Hyde Park, Boston, Mass., announces the appointment of R. G. Ingram to supervise its sales agencies in the Middle West. Mr. Ingram will maintain his headquarters at One La Salle St., Chicago, Ill.

J. B. GILLHAM and G. A. Anderson of the Reliance Electric & Engineering Co., Cleveland, Ohio, have been sent to Los Angeles and San Francisco offices respectively of the Utilities Equipment Corp., sales and service representative for the Reliance company on the Pacific Coast.

FIRST UNIT in what is expected to develop into a great hydro-electric project at the Big Bend in the Missouri River, 25 mi. west of Chamberlain, S. D., under the General Manganese Corp., Detroit, Mich., and its recently organized utility subsidiary the Oacoma corporation, was started recently. A half-million dollar manganese mining plant and hydroelectric power plant, which will develop 16,000 hp., will be under way soon. Primary purpose is development of the estimated 100 million tons of manganese in the Missouri river valley, extending a distance of 60 mi. in the Chamberlain territory but the hydroelectric project will eventually equal the mining undertaking in scope and investment. William Gordon, Sioux City, is president of the Oacomo corporation, the electric power company; A. R. Newman, president of the First National bank, Pukwana, S. D., vice president and John Ansher, Chamberlain, treasurer; and O. S. Dean, Sioux City, secretary.

COMPLETION of the new 12,500-kw. power unit at the Dubuque, Iowa plant of the Interstate Power Co., which is now under way, will finish replacement of the old power generating equipment at the plant which has increased its production capacity to 40,000 kw. C. E. Dove, manager of the division, stated that this will complete the program of centralization of generation at the Dubuque plant, which has been rebuilt and entirely reëquipped since Interstate acquired possession.

FEDERAL CONSTRUCTION Co., representing an eastern syndicate, will appear before the Iowa state board of conservation June 9 in Des Moines for hearing upon application for permit to construct a hydroelectric plant near Muscatine in Muscatine county, Iowa, which will have initial capacity of 138,000 hp. larger than the Keokuck dam and will represent eventual investment of $18,000,000. The petitioners propose a dam on the Cedar river at Moscow with seven-mile canal from this point to the Mississippi river, three miles east of Muscatine, where the power station will be erected. The company is negotiating for rights to 30,000 acres of land in the vicinity necessary to the project.

I. C. MCLAIN has been appointed district manager for the Missouri Public Service Corp. with headquarters in Kansas City, Mo. and will assume his new position June 16. He has been Tuscola, Ill., manager for the Central Illinois Public Service the past year.

PALMER-BEE Co., Detroit, Mich., has opened a district sales office in New York at 30 Church St., Suite 308, in charge of H. W. Ruth.

E. A. DOYLE, consulting engineer of The Linde Air Products Co., was elected president of the American Welding Society at the annual meeting of the society held April 25, 1930.

WESTERN KENTUCKY Electric transmission system of the Kentucky Utilities Co. will be considerably strengthened with the resumption of operation of the 5300-hp. generating station at Paducah, in which four 300-hp. boilers have been replaced with a single Stirling type boiler with Bailey water walls, fired with powdered coal and having an operating rating of 1800 hp. and more. The improvement has been under way for several months. It has entailed a partial reconstruction of the building. Test operation of the new equipment took place during the first half of May and service operation was scheduled to start on May 20. The improvement has cost approximately $180,000. The company's western Kentucky transmission system receives electric energy from power stations at Earlington, Graham and Paducah. It is interconnected with a large transmission system in southern Illinois.

THE FEDERAL GOVERNMENT recently granted the Baton Rouge Electric Co. a permit covering the erection of a 66-kv. transmission line over the Mississippi River at Baton Rouge, La., on two 425-ft. towers, as a part of a line now nearing completion by the Stone & Webster Engineering Corp. The towers, according to Government representatives, are the tallest river crossing towers in this country. The line will transmit power from the new Louisiana Station of Louisiana Steam Products, Inc., a constituent company of Engineers Public Service Co., across the river to the existing system of the Baton Rouge Electric Co. and also to the Gulf States Utilities Co.

The permit was granted with the provision that the wires clear high water at a minimum height of 150 ft. and that the towers be painted black and white and also be brightly illuminated in order that they may not be a hazard to aviation.

EDWARD VALVE & MANUFACTURING Co. has appointed Riffe & Thomas, Inc., successor to the W. A. Ross Co., Charleston, West Virginia, as its representatives. Headquarters are at Charleston, West Virginia.

IT IS ANNOUNCED by Lee Skipwith of the Burke Controller Corp. and the management of Ward Leonard Electric Co., that the entire physical assets of Burke Controller Corp. have been purchased by Ward Leonard. The present factory of Burke Controller will be moved to the Ward Leonard plant at Mount Vernon, N. Y. The manufacture of the various Burke products will be continued at the Ward Leonard plant.

W. H. HODGE, vice president and manager sales and advertising department of the Byllesby Engineering and Management Corp., Chicago, Ill., announces the following departmental changes: T. P. Pfeiffer has been appointed advertising manager of the Byllesby Engineering and Management Corp. and Standard Gas and Electric Co. J. W. Hicks has been appointed publicity director of the Byllesby Engineering and Management Corp. and Standard Gas and Electric Co., also remaining in charge of the publications of these companies issued for executives, employes, etc.

JOHN J. O'BRIEN, president of H. M. Byllesby and Co., Chicago, Ill., announces that J. F. Gardiner has been appointed advertising and publicity manager of H. M. Byllesby and Co.

GULF REFINING Co., Pittsburgh, Pa., has awarded a contract to United Engineers & Constructors, Inc., for the construction of extensions to the bulk storage plant on Staten Island, New York, to cost approximately $2,000,000. The present Staten Island storage plant, which was completed by United Engineers & Constructors early this year, has already proved to be inadequate for the company's business in the New York district and the additional capacity has been found necessary. Construction will begin immediately.

HALFORD ERICKSON, vice president in charge of operation, Byllesby Engineering and Management Corp., Chicago, Ill., announces that the electric generating station under construction at Granite Falls, Minnesota, for Northern States Power Co., has been officially designated as the Minnesota Valley Steam Electric Plant.

CONSTRUCTION on the four major engineering projects now under way for companies in the Standard Gas and Electric Co. system is proceeding rapidly and in line with schedules outlined, according to H.W. Fuller, vice president in charge of engineering and construction, Byllesby Engineering and Management Corp.

The largest project, the James H. Reed station of 60,000 kw. capacity being built on Brunot Island in Pittsburgh for the Duquesne Light Co., is, so far as the engineering work is concerned, nearing completion. More than 1200 men are employed on the project at this time. The station, described in the April 1 issue of Power Plant Engineering, is scheduled to be ready for operation on August 1, 1930.

Substructure work on the 30,000-kw. capacity station being built at Belle Isle in Oklahoma City for the Oklahoma Gas and Electric Co. is practically complete; 325 men are employed on this project, which is scheduled for completion on September 15, 1930.

The Minnesota Valley Steam Electric Plant being erected at Granite Falls, Minnesota, for Northern States Power Company, will have a capacity of 20,000 kw. Excavation of the entire power house area is completed, lower foundation mats have been poured except one opening and all substructure walls, beams, columns and turbine supports have been poured including electric gallery subbasement walls and electric gallery floor. Work of setting stone and brick on the south and west walls has been started. This plant is scheduled for completion on November 1, 1930. About 215 men are employed on this project.

Satisfactory progress is also reported on the 10,000-kw. addition to the Coos Bay station of Mountain States Power Company at North Bend, Oregon, which is scheduled for completion on July 1, 1930. The new addition will include one 10,000-kw. turbine with two boilers of suitable capacity. The boilers were completed on June 1. The brick work for the boilers has been completed and a drying out fire was started in one boiler on May 12. About 90 men are employed on the Coos Bay project.

HALFORD ERICKSON, vice president in charge of operation, Byllesby Engineering and Management Corp., has announced that plans are being made for construction of a 110-kv. wood pole, H frame transmission line between the Wissota hydroelectric plant of Northern States Power Co. and the Wisconsin Valley Electric Co.'s hydroelectric station at Wausau, Wis. Construction is scheduled to start on this project in the immediate future and the line is scheduled for completion about November 1. Engineering on the project will be done by Byllesby Engineering and Management Corp. and the line will be owned by Wisconsin Valley Electric Co.

R. F. PACK, vice president and general manager, Northern States Power Company, has announced plans for the company's new office building which is to be erected at Fifth and Wabasha Streets in St. Paul, Minn., as the first definite step in the development of the Court House Square. The building will conform with the general scheme for the improvement and development of the City Hall and Court House Square soon to be vacated by this combination public building in St. Paul.

STEPHENS-ADAMSON MFG. Co., Aurora, Ill., announces the removal of its New York sales and engineering office to 50 Church St., Room 1360, New York City.

ANNOUNCEMENT is made that the Ohio Steel Foundry Co. of Lima and Springfield, Ohio, has purchased the steel foundry department and steel casting business of the Industrial Brownhoist Corp. of Cleveland, Ohio, and Bay City, Mich. The steel foundry itself is located at Bay City and will be operated there by the Ohio Steel Foundry Co., beginning May 1.

TERRY STEAM TURBINE Co. announces that S. O. Maxwell has been appointed district manager of its New York office at 90 West St., New York City. Mr. Maxwell, who has been with the company since 1925, has been assistant New York manager for the past few years.

DIRECTORS of the Jeffrey Manufacturing Co., Columbus, Ohio, at a meeting held May 7, elected J. Frank Davidson to the position of vice president and assistant general manager. Mr. Davidson has been associated with the Jeffrey Manufacturing Co. since 1911. Prior to his election to the vice presidency he was assistant general manager and had previously served as purchasing agent in charge of purchases and stores. In addition to his position with the Jeffrey Manufacturing Co. he is a director of the Ohio Malleable Iron Co.

GRAVER TANK & MANUFACTURING CORP. of East Chicago, Ind., has recently been awarded contracts for water softening equipment for two railroads. The first contract is for a large water softener to be installed for the C. St. P. M. & O. R. R. at Mankato, Minn. This softener is the Graver cold process type with a softening capacity of 35,000 g.p.h. The settling tank will be 31 ft. 6 in. in diameter and 62 ft. high. In addition to its treating capacity it will have storage space for 185,000 gal. Graver meter type chemical control will be used. The meter will be an 8 in. Sparling and the chemical tank 8 ft. in diameter by 4 ft. 6 in. high.

The second contract is for a water softener to be installed at Manchester, N. Y., for the Lehigh Valley R. R. This, it is stated, is one of the largest softeners bought by any railroad for some time. The settling tank is 47 ft. in diameter and 49 ft. high with softening capacity for 68,000 g.p.h., in addition to storage space for 150,000 gal. Chemical feed is controlled with the Graver meter control using a 10 in. Sparling meter.

Catalog Notes

IMPROVED Webster Type "R" System of Steam Heating is described and illustrated in a new eight-page bulletin by Warren Webster & Co., Camden, N. J. Detailed sketches compare the various phases of operation of the type R system with the other types of heating systems. Details of valves and radiators are also shown.

NORTON PULPSTONES, a factor in Pulp Production, is the title of a new 16-page bulletin issued by Norton Co., Worcester, Mass., describing the construction of these stones and the method of using them to grind wood used in making paper.

BEHIND THE PYRAMIDS is the title of a recent well-illustrated bulletin describing the processes used in making carbon brushes, with illustrations of each step in the process. The bulletin is issued by National Carbon Company, Carbon Sales Division, Cleveland, Ohio.

RUTHS ACCUMULATOR PLANTS in Power Stations are described in a well-illustrated, 20-page bulletin issued by Ruths Accumulator A. B., Stockholm, Sweden. Detailed descriptions are given of the installations in such plants as the Malmo Municipal station, Halmstad Municipal station, Hamburg Elevated Railway Power Station, North Leipzig Heating and Power Station, Charlottenburg station and several others. Load diagrams are given, as well as single-line diagrams showing the connections and steam conditions; photographs of the installations, together with technical data, are given in each case. In another bulletin, the company describes the Ruths Steam Storage Installation at Charlottenburg station of the Berlin Municipal Electricity Works. The accumulators are illustrated, details of their construction and transportation to the plant are shown and the illustrations of the turbines used in connection with them are given.

SPEER CARBON PRODUCTS are described in a loose-leaf, 56-page bulletin, catalog No. 24, issued by Speer Carbon, St. Mary's, Penna. The bulletin discusses flashlight and radio carbons, characteristics of various types of brushes, description of various installations and other data and description of carbon contacts, specialties, packing rings, resistance units and other carbon products made by the company. Photographs show the appearance of carbons, dimension drawings and shunt locating drawing are shown and tables of sizes and shapes are given.

IN BULLETIN GEA-1262, the CR9504 Operator, a self-contained, hydraulic device designed to exert a smooth, straight-line thrust in one direction throughout a definite distance is designed by the General Electric Co., Schenectady, N. Y. Details of this device were given in the December 1, 1929 issue of Power Plant Engineering.

IN BULLETIN GEA-1266, the CR7505-A1 Photo-electric Relay is described by General Electric Co., Schenectady, N. Y. This is designed for control of electric circuits in response to an increase or decrease in the amount of light falling on a photo-electric tube. The device is described and illustrated in detail.

SULLIVAN Vibrationless Portable Air Compressors are described in Catalog 83-R by the Sullivan Machinery Co., Chicago, Ill. In this 40-page, letter-size bulletin, printed in two colors, the line of portable gasoline engine driven compressors is described which has recently been increased by the addition of a 66-ft. unit. Details of the parts and their dimensions are shown and many illustrations show the use of equipment in the field, in engineering construction work and many other applications. Description is also given of Sullivan portable electric driven units.

DESIGNED TO BE a comprehensive handbook explaining in full the theory, characteristics, operation and installation of the centrifugal pump, Bulletin 401, compiled by F. G. Switzer, Professor of Hydraulic Engineering, College of Engineering, Cornell University, Ithaca, N. Y., has just been issued by Goulds Pumps, Inc., Seneca Falls, N. Y. The bulletin is intended to be a practical handbook of engineering data for the student, the engineer and the pump operator. Complete details of pump testing are shown. The theory of the centrifugal pump is discussed and the subjects of balancing end thrust, suction lift, methods of drive and pump installation are fully covered. Many tables and diagrams show various relations between quantities and the bulletin concludes with some interesting illustrations of pump applications.

ELECTRIC FLOW METER instruction book, a 40-page, 8 by 10½-in. illustrated bulletin, No. 214, has recently been issued in a revised edition by the Brown Instrument Co., Philadelphia, Pa. This explains the mechanism of various types of Brown flow manometers, indicators and recording instruments, gives instructions for installing the equipment, adjusting instruments for zero readings and changing range tubes. The new low range manometer is discussed in some detail, practical suggestions for avoiding difficulties are given and tables of correction factors for pressure, quality and superheat of steam are presented.

STEAMATIC Ash Conveying System, a pneumatic pipe line conveyor in which a high velocity air flow is produced by a steam ejector at the discharge end of the line, is described in an attractively-illustrated, 16-page catalog by United Conveyor Corp., Old Colony Bldg., Chicago, Ill. Photographs of installations, efficiency curves, details of the parts and piping layouts of the conveyor are shown in two colors.

AN ELECTRICAL METHOD for the determination of the dew-point of flue gases, by Henry Fraser Johnstone, Special Research Associate in chemical engineering, has recently been issued as circular No. 20 by the Engineering Experiment Station of the University of Illinois at Urbana, Ill. This discusses in the introduction the importance of determining dew-point of flue gas, previous estimates, difficulties in determining the dew-point. It then proceeds to describe an electrical method, discussing the principle, the accuracy of the method, the apparatus needed and results obtained. Calculation of dew-point from sulphur trioxide and water vapor content of flue gases is also discussed. As a result of investigation, it is concluded that it is possible to record the dew-point of furnace gas by an electrical device based on the conductivity of a glass surface.

INSTRUCTIONS for mixing and application of Enco Baffle Material are given in detail in a recent bulletin, EB-428, by the Engineer Co., 17 Battery Place, New York City.

LABORATORY TESTS of Reinforced Concrete Arch Ribs, by W. M. Wilson, Research Professor of Structural Engineering, are presented in bulletin No. 202 issued by the Engineering Experiment Station, University of Illinois, Urbana, Ill. This describes the specimens and apparatus used, the properties of arch rib, the tests made and the results of the tests. The bulletin is well illustrated, many of the findings being presented by diagrams and curves and by tables of data.

IN A RECENT BULLETIN entitled How Beco Baffles Modernize Old and New Water Tube Boilers, the Boiler Engineering Co., 24 Commerce St., Newark, N. J., shows the methods of baffling all types of horizontal and bent tube water tube boilers.

BOILER AND TURBINE ROOM INSTRUMENTS are discussed in detail in N.E.L.A. Publication No. 038 recently issued by the Prime Movers Committee, Engineering National Section, National Electric Light Association, 420 Lexington Ave., New York City. Increasing use of smoke measuring and detecting instruments and results secured with different types are reported. Experience with liquid in glass, metal bulb and capillary tube and electrically operated thermometers is included. Conditions of installation and use to secure accuracy and reliability are discussed. Requirements for a fundamental plan of temperature measurements in a power plant are suggested. Several schemes of instrument location and use for facilitating apparatus control are described. Increased use of remote indicating instruments for centralized control is noted. A quick method for checking and adjusting the airflow mechanism of a boiler meter is described.

HAYS FLUE GAS ANALYZERS and portable combustion test sets, new model, are described and illustrated in detail in Catalog TSE-30 just issued by the Hays Corp., Michigan City, Ind. Fundamentals of combustion are discussed, details of the analyzers are illustrated and described and detailed instructions are given for using them.

METAL-CLAD SWITCHGEAR for indoor and outdoor service is described and illustrated in bulletin GEB-80 by General Electric Co., Schenectady, N. Y. In bulletin GEA-158C portable instruments are described, Type P-3 for alternating current and Type DP-2 for direct current. Line-Type lightning arresters are described in GEA-93G. Automatic time switches, "Telechron" Motor-operated for use on alternating current circuits with regulated frequency, are described in bulletin GEA-913C.

DETROIT MULTIPLE RETORT STOKERS are illustrated and described in a new 32-page bulletin recently issued. The principle of the level fuel bed, designed to prevent avalanching, double control of the flow of fuel and its distribution in each retort, graduated distribution of air, use of side wall wind boxes, power operated dump for large stokers are illustrated and described in detail. Wide choice of setting arrangements is shown and method of ash removal is described. The bulletin is published by the Detroit Stoker Co., General Motors Bldg., Detroit. Many illustrations of stoker parts, boiler and furnace arrangements and actual installations are presented.

BENZIDINE METHOD for Determining Sulphates in Water is described in bulletin 26 by National Aluminate Corp., 6216 West 66th Pl., Chicago, Ill. Method of conducting the tests, precautions to be taken and equipment necessary are discussed in detail. In bulletin No. 9-A, the company describes and illustrates a flexible and scientific method of treating feedwater in the boiler.

INDUSTRIAL HAULAGE locomotives trolley type—60 ton—are described in bulletin GEA-1229, just issued by General Electric Co., Schenectady, N. Y. Automatic switching equipment for indoor A-c. reclosing feeder service is described in bulletin GEA-189B. Miniature instruments are described in catalog GEA-1239. Industrial Control Catalog GEA-606B is a 200-page, illustrated book, describing completely all types of industrial control equipment.

REPORT on Preferred Voltage Ratings for Alternating Current Systems and Equipment, under preparation by a joint committee during the last two years, has just been issued by the National Electrical Manufacturers' Association and the National Electric Light Association. Schedules of preferred voltage ratings are given for generators, motors, transformers and general apparatus such as disconnecting switches, fuses, oil circuit breakers and so on.

The associations which issued the report feel that if these ratings are applied so far as practicable and as rapidly as conditions will permit, considerable financial benefits will result through use of standard apparatus and parts instead of special. There will be less development cost, greater quantity production and more satisfactory replacement and repair service.

The ratings are based on the principles in the report of the joint committee issued in October, 1928. Later, detailed schedules and tables of preferred voltages for various classes of apparatus were worked out for practical application and are included in the publication. This is the first document which contains all the preferred voltages and principles under one cover.

Copies may be obtained from either association at 420 Lexington Ave., New York, N. Y. The price is 30 cents to members and 50 cents to non-members. Discounts are allowed on quantity orders.

CORRECTION.—The address of the Boiler Room Improvement Co., given in a catalog note published on page 601 of the May 15, 1930 issue, was the old address of the company, which has now been changed to 4057 West Van Buren St., Chicago, Ill.

Power Plant Construction News

Ariz., Phoenix—The Board of Public Works is said to be planning installation of power and pumping machinery, with auxiliary equipment, in connection with extensions and improvements in municipal waterworks, for which a bond issue of $2,941,238, is being arranged. W. J. Jamieson is city engineer.

Calif., Richmond—The Ford Motor Co., Dearborn, Mich., will install electric power equipment in proposed new assembling plant on tract of land recently acquired at Richmond, entire project reported to cost over $2,000,000. A steam power plant is projected. Bids will soon be asked on general contract.

Colo., Denver—The Continental Oil Co., Continental Oil Building, plans installation of electric power equipment in proposed new oil refining plant on the Brighton Road, entire project to cost close to $1,000,000.

Conn., Bridgeport—The Southern New England Ice Co., Bridgeport, will remodel and improve a building on Hallam Street, and will install equipment for a new one-story ice-manufacturing plant.

Conn., Stamford—The Norma-Hoffman Bearings Corporation, Hamilton Street, plans installation of electric power equipment in proposed one and two-story plant addition, to cost over $125,000. Fletcher-Thompson, Inc., 542 Fairfield Avenue, Bridgeport, Conn., is architect and engineer.

D. C., Washington—The Potomac Electric Power Co., Washington, will soon begin superstructure for proposed new addition to steam-operated electric generating plant at Bennings, near Washington, reported to cost more than $1,000,000. The Stone & Webster Engineering Corporation, 49 Federal Street, Boston, Mass., is engineer.

Ga., Atlanta—The Department of Public Works, City Hall, is planning construction of a two-story addition to boiler plant, 30x42 ft., at Chattahoochee, reported to cost close to $28,000, with equipment.

Idaho, Pocatello—The Pacific Fruit Express Co., 64 Pine Street, San Francisco, Calif., plans installation of additional mechanical equipment in connection with proposed enlargement of car-icing plant at Pocatello, project to cost about $50,000.

Idaho, Sandpoint—The City Council is arranging for the sale of a bond issue of $3,000,000, proceeds to be used for the construction of a municipal hydroelectric generating plant on the Priest River.

Ill., Chicago—The Aridor Co., 589 East Illinois Street, plans installation of electric power equipment in proposed new metal cap manufacturing plant on West Forty-eighth Place, entire project to cost about $140,000. A. Epstein, 2001 West Pershing Road, is architect and engineer.

Ill., Chicago—Borden's Farm Products, Inc., 326 West Madison Street, plans installation of electric power equipment in proposed new bottling plant on West Seventieth Place, entire project to cost over $300,000. E. E. and E. C. Roberts, 105 North Clark Street, Chicago, are architects.

Ill., Neoga—The Watson Orchards, Inc., 236 North Clark Street, Chicago, Ill., R. A. Watson, manager, is reported to be planning the installation of a cold storage refrigerating plant in proposed addition to fruit-packing plant at Neoga, entire project to cost more than $150,000.

Ill., Rockford—The Rockford Electric Co., Chestnut Street, has approved final plans for a new power substation near Rockford, reported to cost about $40,000, with equipment.

Iowa, Creston—The Common Council has plans under way for a filter plant for municipal water service, estimated to cost about $30,000. The Currie Engineering Co., State Bank Building, Webster City, Iowa, is consulting engineer.

Kans., Hoxie—The Central Kansas Power Co., Abilene, Kan., plans one-story and basement addition to power plant at Hoxie, to cost over $35,000.

Me., Rumford—The Oxford Paper Co. has approved plans for consturction of a steam-operated electric power plant at local mill, reported to cost over $85,000, with equipment. Charles T. Main, Inc., 201 Devonshire Street, Boston, Mass., is consulting engineer. It is understood that contract for building has been let to the Morton C. Tuttle Co., 31 St. James Avenue, Boston.

Mich., Muskegon—The Brunswick-Balke-Collender Co., Laketon Avenue, manufacturer of billiard tables, etc., plans installation of electric power equipment in new multi-story addition to local plant, entire project to cost about $100,000.

Mont., Great Falls—J. M. Murphy, Great Falls, has secured a franchise for the construction and operation of a central steam power plant for heating service, estimated to cost about $100,000. C. P. Wells is city engineer.

Mo., Campbell—The City Council will take bids at once, it is said, for a municipal electric light and power plant to cost about $80,000, with equipment. Russell & Axon, 6200 Easton Avenue, St. Louis Mo. are engineers.

N. J., Hackensack—The Hackensack Water Co. has secured permission to issue common stock for $2,562,000, and notes in amount of $3,000,000, portion of fund to be used for extensions and betterments in plants and system.

N. Y., Clifton Springs—The Village Council is said to be planning the installation of pumping machinery and auxiliary equipment in connection with extensions and improvements in municipal waterworks. A bond issue of $60,000 is being arranged for the project.

N. Y., Kingston—J. Forst, Inc., Kingston, plans installation of electric power equipment in proposed two-story meat packing plant on local site, entire project to cost more than $125,000. A building permit has been issued. O. S. Schlich, 136 Liberty Street, New York, is engineer.

Ohio, Cleveland—The Fisher Body Corporation, General Motors Building, Detroit, Mich., a subsidiary of the General Motors Corporation, same address, plans installation of electric power equipment in proposed addition to automobile body plant at Cleveland to cost about $500,000.

Ohio, Toledo—The Toledo Scale Co., Toledo, will install electric power equipment in proposed new factory unit, for which final plans have been approved, entire project to cost over $1,000,000. A building permit has been issued.

Ohio, Youngstown—The Ice & Fuel Co., 1421 West Federal Street, is completing plans for a two-story ice-manufacturing plant at Avondale and South Boulevards, to cost about $150,000, with machinery. G. B. Bright, 2615 Twelfth Street, Detroit, Mich., is engineer.

Okla., Filburton—The Common Council has preliminary plans in progress for a municipal electric power plant, Diesel engine type, to cost about $35,000, with equipment. V. V. Long & Co., Colcord Building, Oklahoma City, Okla. are engineers.

Pa., Philadelphia—Archibald Holmes & Sons, Allegheny Avenue and A Street, have filed plans for a one-story boiler plant in connection with four-story addition to textile mill, entire project to cost more than $250,000. M. Ward Easby, 1505 Race Street, is architect.

Pa., Philadelphia—Leas & McVitty, Inc., 303 Vine Street, has filed plans for a one-story boiler plant at leather tannery at Langdon and Foulkrod Streets.

Pa., Philadelphia—Philadelphia Gas Works Co., 1401 Arch Street, has filed plans for extensions in artificial gas plant on Schuylkill Avenue, estimated to cost about $30,000.

Texas, Denton—The Common Council is said to be planning the installation of an ice-making and refrigerating plant in municipal utilities building, and will ask bids for equipment at an early date.

Texas, Harlingen—Valley Baking Co., Harlingen, plans installation of traveling ovens, steam and electric power equipment in proposed new baking plant to cost about $300,000. Work is scheduled to begin at early date.

Utah, Ogden—The Sperry Flour Co., Fourth and Berry Streets, San Francisco, Calif., plans installation of electric power equipment in new feed milling plant at Ogden, for which appropriation of about $125,000 has been arranged. H. P. Iverson is local manager.

Wis., Oconto—The City Council has plans under way for extensions and improvements in municipal waterworks to cost about $38,000, including installation of electric-driven deep-well pumps and accessories. Gordon & Bulot, 53 West Jackson Boulevard, Chicago, Ill., are engineers.